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BEAR DEPREDATIONS ON RED SALMON SPAWNING POPULATIONS IN THE KARLUK RIVER SYSTEM, 1947

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INTRODUCTION

Observers watching the migrations of mature salmon into the streams and rivers of Alaska long have been aware that the depredations of feeding bear result each year in the loss of large numbers of potential spawners, and that this loss is great enough to be of considerable economic importance. The depredations are especially heavy in regions inhabited by the great Brown or Kodiak bear, *Ursus middendorffi*. The author has observed these depredations and their results in various parts of Alaska during the past ten years, particularly on Baranof Island, in the territory surrounding Bristol Bay, and at Karluk Lake, on Kodiak Island. At the latter place, studies made in 1947 make it possible to measure the minimum loss of fish to these animals and to show that this loss is not only economically important, but that it constitutes a very serious threat to the perpetuation of the runs of red salmon, *Onchorhynchus nerka* (Walbaum), which are produced within the Karluk system.

DECLINE OF KARLUK RED SALMON POPULATIONS

Karluk Lake, located in the western part of Kodiak Island (Figure 1) is drained by the Karluk River which is approximately 30 miles in length, emptying into Shelikof Strait. The lake is 12 miles long by 2 miles in width at its widest point and has an area of approximately 14.6 square miles (Gilbert and Rich, 1927). Surrounded by mountains except at its northern extremity, it is fed by numerous small streams, the waters of which are clear and cold. These streams provide excellent spawning facilities for red salmon and for many years this system probably produced more of these fish than any other system of comparable size.

The Karluk red salmon fishery began in 1882 and developed rapidly until 1889, when more than 3 million fish were caught (Barnaby, 1944). For the next five years this level was maintained, but thereafter a successive decline ensued and less than 0.5 million fish now are taken annually. While catches are subject to many variables, such as fishing intensity, availability, and economic conditions, it is believed that at Karluk they are a reasonably good index of abundance, and it is further believed that the escapements (spawning populations) have decreased proportionately to the decrease in abundance. By *a posteriori* reasoning, the

escapements prior to the advent of commercial fishing must have been at least 3 million fish annually. In the first ten years of operation of the Karluk weir (1921–1930) the mean annual escapement was 1.2 million, while for the past three years the mean escapement was only 0.4 million (Shuman, 1948). Thus the fishery is in a depleted condition and factors which act on the remaining stocks in a deleterious manner become of increasing importance and concern.

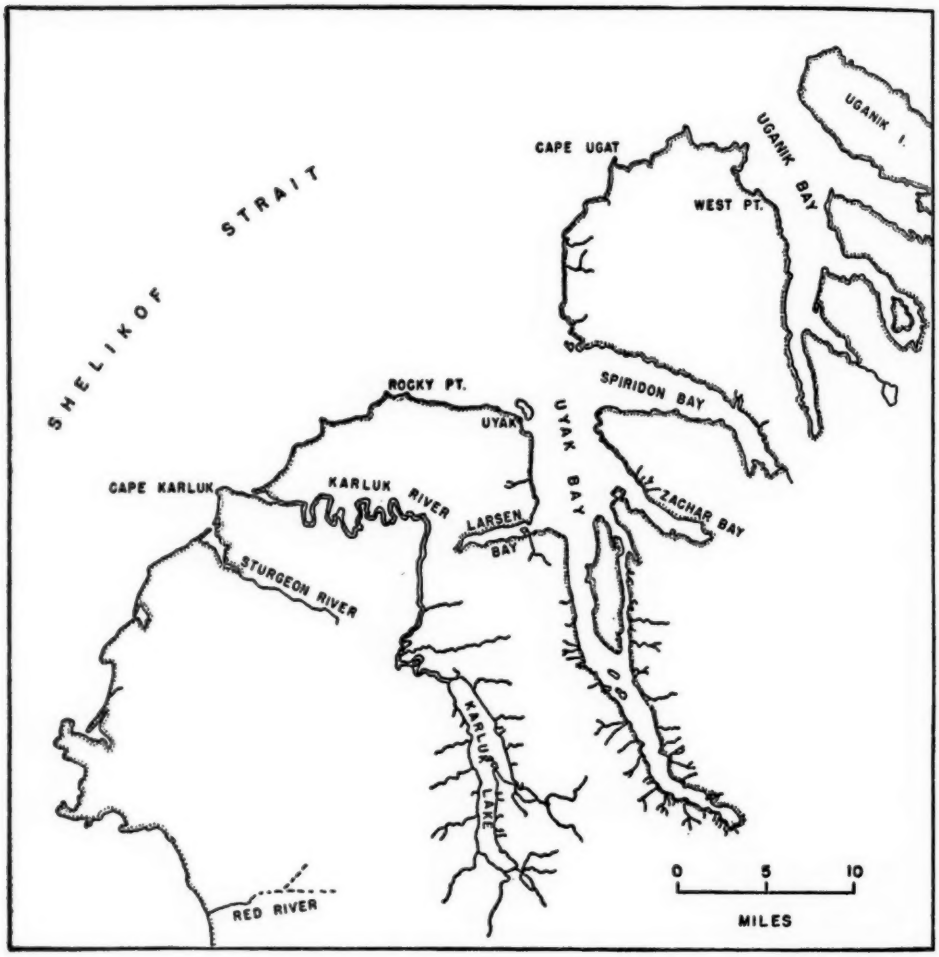

FIG. 1. Karluk Lake and the western end of Kodiak Island.

IMPORTANCE OF PREDATION

So long as the spawning fish are numerous enough to provide ample food for the predator population and so long as this population is constant, approximately the same number of fish will be taken each year regardless of

the number of fish available. Under these conditions, as the fish decrease in number depredations become more significant, since the predators will take an increasingly higher percentage of the escapement each year. The loss of a given number of spawners is relatively unimportant when the escapements are numbered in millions; the same loss can be alarming when the escapements are as low as they have been in recent years.

Predation in the Karluk area is caused almost entirely by Kodiak bear, since no other species of bear are present, while fox, eagles, otter, and other predators take only an insignificant number of spawning fish. Observations made at and around the lake in recent years indicate that there has been no decline in the bear population; indeed, there appears to have been a marked increase, probably brought about by the absence of hunters during the war years, through natural increment, and by migration from areas occupied by military installations. Karluk Lake is not unique in this respect, for Marcus Meyer, Fish and Wildlife Agent for the Kodiak District, reports a similar increase in the bear population around Red River.

The depredations and importance of bear in the Kodiak area first were discussed by the author in the Report of Activities for the Section of Alaska Fishery Investigations for July, 1945. A part of that report reads, "Throughout the season it was observed that the loss of spawning salmon to the bear was enormous, the smaller streams suffering a relatively higher loss than the larger ones. On several of the small streams it was found that the bear were destroying every salmon entering to spawn. While no one of these streams is of great importance in itself, the aggregate loss has been considerable. Certainly tens of thousands of potential spawners have been destroyed in these small streams. . . . "

"It was estimated by members of the Karluk field party . . . that between 25 per cent and 33 per cent of all salmon reaching the spawning streams are destroyed by bear. . . . "

Other reports by the author in the following year stated that the conditions were but little changed; however, it was not until 1947 that pertinent data could be obtained. These data indicate that the loss of spawning red salmon was greater in recent years than estimates had indicated.

Observations made on the spawning streams over a period of several years have shown that bear-killed fish almost always are mutilated in such a manner that the cause of death is obvious, teeth-marks or claw-marks on the dead fish being quite noticeable. Bear often remove one bite from the back of fish they have killed, the bite being taken at or near the nape, but many of the fish are killed and left with no part being eaten. Many fish are carried away from the streams, some to be eaten entirely (a rare occurrence when fish are plentiful), some to be left partially or completely undevoured. These carcasses often are found at a distance of several hundred yards from the nearest stream. Because of the nature of the country, it is impossible to count these carcasses, and other work in 1947 precluded any program of enumerating this loss. However, it was felt that data could be obtained which would make it possible to determine the number of fish which were destroyed by the bear and left in the stream.

METHOD OF STUDY

Throughout the 1946 and 1947 field seasons fresh-water tagging programs were conducted in order to establish the existence or non-existence of races within the Karluk red salmon populations. As an adjunct to this work, a small weir was constructed at the mouth of Moraine Creek in 1947. This creek was chosen partly because of its proximity to the Karluk River field station and partly because it is a stream typical of those flowing into Karluk Lake and used by spawning salmon. During the time when fish were entering Moraine Creek, daily counts of escapements were made. The weir was in operation for an extended period each morning and each evening and, during the height of the run, for the entire day. Besides escapement counts, a record was kept of all dead fish which drifted downstream to the weir. These carcasses were disposed of by throwing them over the weir to drift down to the lake, a distance of about 30 feet. Before this disposal, each carcass was examined to determine the cause of death and also to determine whether or not the fish had completed spawning at the time of its demise. As was anticipated, many of the fish had spawned but partially. When an examination of the gonads showed a fish to have completed less than one-half its spawning function that fish was recorded as unspawned; when more than half had been completed it was recorded as spawned out.

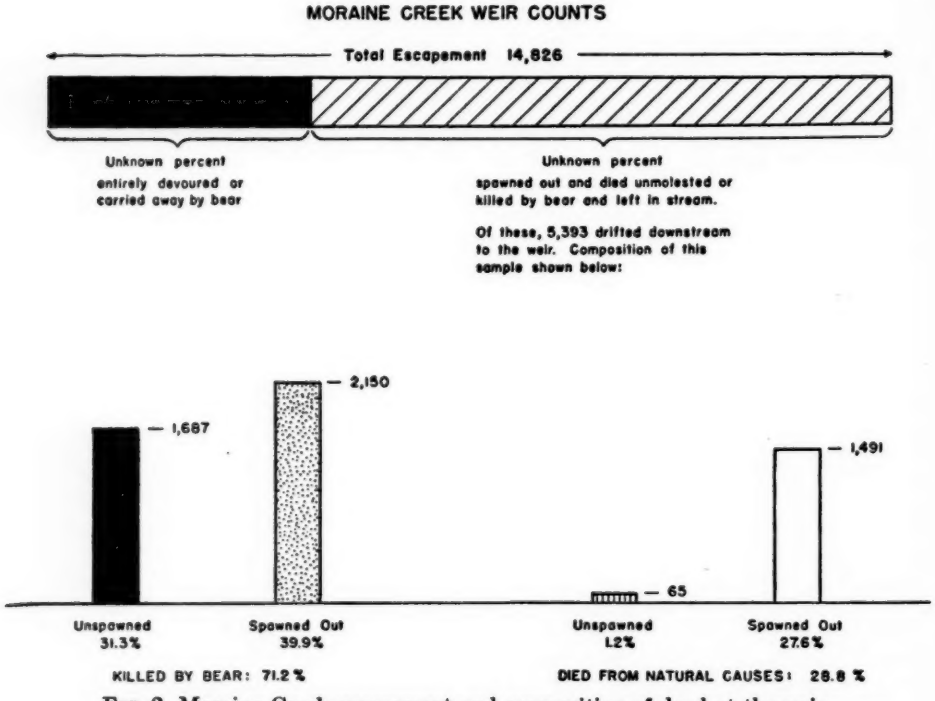

FIG. 2. Moraine Creek escapement and composition of dead at the weir.

No fish was recorded as having been killed by bear unless the evidence was conclusive. In all cases where the cause of death could not be ascertained, it was credited to natural causes. Because of decomposition, many carcasses drifted to the weir broken into parts or pieces of various sizes; to avoid a duplication of counts, only the cranium was counted as one fish. Although bear undoubtedly had killed many of these fish, the cause of death could not be ascertained and they were all recorded as having died natural deaths, thus undoubtedly understating the actual bear kill.

During the season 14,826 red salmon entered Moraine Creek. Of these, 5,393 later drifted back dead against the weir. The results of the examinations of these carcases are presented in Figure 2.

Many of the fish were eaten or removed from the stream by bear; although this number is not known, observations on the various streams give reason to believe that they constituted at least 25 per cent of the entire escapement. Of the fish remaining in the stream (both those killed by bear and those dying naturally), 5,393 drifted downstream to the weir. This can be considered as an unusually large sample (36.4 per cent of the entire escapement).

Observations made on the stream failed to show that there was any greater tendency for bear-injured fish to swim downstream than for fish dying from natural causes, nor for bear-killed fish to drift down more readily than those which had died unmolested. There appears to be no selectivity in the sample, and it follows that the composition found within the sample probably applies to that part of the population left in the stream. It is not possible to apply the ratios to this group, since it is not known how many fish were carried away. However, the escapement size is known, and it is reasonable to apply the ratios found in the sample to the escapement as a whole. When this is done the following figures are obtained:

Escapement: 14,826	
Killed by bear, unspawned	4,640
Killed by bear, spawned out	5,916
Died naturally, unspawned	178
Died naturally, spawned out	4,092
Totals: 14,826	14,826

We are concerned primarily with the number of fish which are killed before spawning, the destiny of those which have completed the spawning function being relatively unimportant. At the Moraine Creek weir, it was found that 31.3 per cent of the sample had been killed before spawning, but it is unlikely that a true picture of the bear depredations is obtained when this ratio is applied to the entire escapement. A considerable portion of the fish in the escapement was devoured by bear, and it is believed that the majority of these fish were killed while yet unspawned. Observations made by the author indicate that in streams such as those at Karluk, where the streams are clear and shallow, where few hiding places occur, and where the fish are relatively abundant and easy to catch, the bear tend to eat only bright, unspawned fish. Therefore, the use of 31.3 per cent as applied to the entire escapement is conservative, and 4,640 is somewhat less than the actual number of unspawned fish destroyed.

LOSS OF UNSPAWNED FISH

It is desirable to measure the loss of unspawned fish for the entire Karluk escapement, computing this loss from the data gathered at the Moraine Creek weir. This computation will be valid

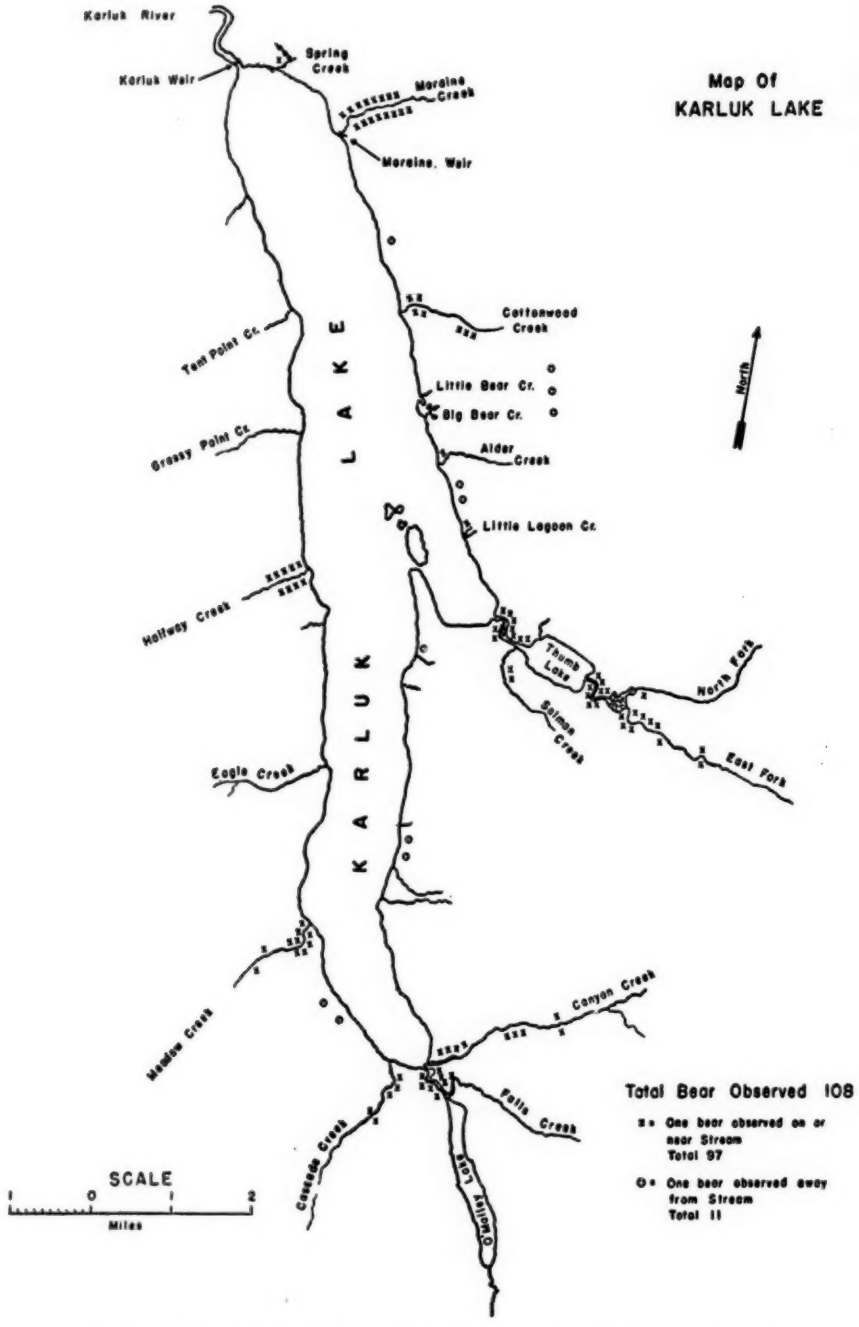

FIG. 3. Karluk Lake and tributary streams, showing bear observed during the 1947 field season.

only if certain questions are answered in a satisfactory manner. These questions are: (1) Is Moraine Creek a representative stream, especially as regards size, depth, current, and hiding places for the fish? (2) Was the bear population on other streams of the lake as great as that on Moraine Creek? (3) Did all parts of the Karluk escapement become equally available to the bear?

As stated before, Moraine is considered to be a representative stream, not differing markedly from others in the area. Two or three of the streams which empty into the lake carry a higher flow of water, while several carry less. In general, all of the streams flowing into the lake are much alike, except for a few very small ones.

There are no counts of the populations of bear on each stream, but data are available which furnish a rather good index of the relative abundance. Figure 3 shows the lake and tributary streams and the number of bear which were observed by members of the 1947 field party, one X on the map representing one bear observed. This does not constitute a population census, since one individual may have been observed several times. However, it does give some clue as to the relative abundance on the various streams. A total of 97 bear were observed on or quite near the tributary streams; in addition, 11 others were seen at considerable distances from the streams or on the mountain sides.

It will be noted that more bear were recorded on Moraine Creek than on any one of several other streams. This indicates a higher relative abundance here than actually obtained, since observations were made on the other streams only at the times of surveys, whereas they were made at Moraine Creek not only at the times of surveys, but also during the operation of the weir. Eighty trips were made to the Moraine Creek weir, with an average time of approximately 1.5 hours spent at the weir for each trip. In addition, there were 8 stream surveys (1.5 hours per survey) so that there was a total of approximately 136 hours of observations on this stream. Sixteen bear were observed, 15 while operating the weir, only one while on stream surveys. An average of 9.3 trips was made to the other streams, with an average time on each stream of about 8.0 hours for the entire season. As an example, 6 trips were made to the Upper Thumb River, with a total of approximately 12 hours spent in the area. During these hours 19 bear were observed.

No bear were observed on Grassy Point Creek, nor on Falls, Little Bear, Big Bear, or Tent Point Creeks, although bear were active on each of these streams throughout the season. Only by chance were no bear seen at these places. With this information in mind, it seems apparent that bear were *not* more numerous on Moraine than elsewhere. Indeed, observations made on the surveys indicated that most of the streams were subjected to far greater bear activity than was Moraine. This was especially true of the entire Thumb System, also of O'Malley, Canyon, Meadow, and Halfway Creeks.

All of the fish in the Karluk run do not become available to the bear; many of them spawn in the lake itself. While a few of these are taken by bear, the loss, probably not great, is ignored in this discussion. It is assumed, however, that all of the fish entering the streams are available to the bear, an assumption

which is justifiable, since all of the tributary streams are small, shallow, clear, and offer little protection to spawning fish.

Tagging and tag recoveries plus observations on the streams indicate that approximately 85 per cent of the spring-run fish enter the tributary streams to spawn, while at least 40 per cent of the fall run fish do so. In 1947, the spring escapement was 237,333 while the fall escapement was 247,416. Thus, 85 per cent of the former, plus 40 per cent of the latter, or 300,699 was the number of fish which became available to the bear during 1947. When the ratios found at the Moraine Creek weir are applied to this number, it can be said that in 1947 a *minimum* of 94,119 salmon were killed by bear before having had a chance to spawn. Conversely, something less than 206,580 spawned out and died naturally in the streams instead of the 300,699 which should have done so. This discrepancy can affect the ratios of return to escapement in a very serious manner, and it is upon these ratios that fundamental studies and control of the fisheries are based. However, it is the loss of the potential spawners which causes concern, not the statistical difficulties which the loss imposes.

The group of fish under consideration has become a complete loss to the red salmon population. It is impossible to calculate this loss in terms of propagation; the results will be far-reaching and will be obscured by many other factors. But it can be stated categorically that when a salmon population is so depleted as the Karluk red salmon population, the loss of 94 thousand potential spawners from the escapement is a serious matter, even though the effects cannot be measured statistically because of other variable factors.

Hubbs (1940) stated the importance of predator control quite well when he wrote, "It should be held prominently in mind that the salmon fisheries have long been of prime importance in the economic exploitation of the Territory, providing the citizens of the United States with an annual profit of about 600 per cent on the original investment of $7,200,000 (the purchase price of Alaska). For years approximately 50 to 85 per cent of the Territorial taxes have been drawn from the commercial fisheries. Unless the food-fish supply is maintained, Alaska will fall at least temporarily into financial and social collapse. If, therefore, the continuity of a profitable fishery is to any considerable extent dependent on the elimination of the natural enemies of salmon, predator control in Alaska assumes the role of a dominant economic necessity."

The data presented here should be ample proof that the existing bear population in the Karluk area is inimical to the survival of the red salmon runs, and that the existence of a valuable resource is being threatened. Elimination or extermination of the bear need not and should not be attempted, but some control of the population urgently is needed. Suitable measures which will bring the population to a reasonable level should be instituted without delay.

SUMMARY AND CONCLUSIONS

The runs of red salmon in the Karluk system presently are in a depleted condition, and predation therefore has become more important to the perpetuation of these runs. In order to measure the loss of potential spawners through

bear depredations, studies of the problem were begun during the 1947 season. The number of fish eaten or removed from the stream by bear was not ascertained, but data were collected which makes it possible to determine the number of fish killed by bear and left in the streams.

It was determined that 31.3 per cent of the fish which entered Moraine Creek, a typical tributary, were killed by bear before spawning, and left partly or wholly uneaten. When this percentage figure is applied to all of the fish which entered the several tributary streams, it can be stated that during the 1947 season at Karluk the minimum loss in unspawned fish was 94,119. Because of the complexities of the problem, no effort was made to evaluate this loss in terms of propagation, but the monetary loss can be determined. Had these fish been added to the commercial pack, their value would have been approximately $117,649.00. Each bear killed in Alaska brings to the Territory an estimated $1,800.00. As six of the animals were killed in the Karluk area by sportsmen, the sum of $9,000.00 must be credited to this resource. Deducting this from the $117,649.00 leaves a net loss of $108,649.00 for 1947. When the condition of the salmon runs is considered, it becomes evident that immediate control of the bear population urgently is needed.

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A MEMORIAL TO JOHN PEARCE

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Maine Cooperative Wildlife Research Unit, Orono, Maine

On April 8, 1949 John Pearce, Regional Director of the U. S. Fish and Wildlife Service and a charter member of the Wildlife Society, died at his home in Natick, Massachusetts. Surviving him are his wife Marguerite, an eight-year old son John, and a five-year old daughter Marguerite. Death came from cancer, after a long illness. With his passing the wildlife profession lost one of its most valuable—and valued—associates. Only 40 years of age, he had reached unusual heights in a brilliant career. In paying tribute to him, Albert M. Day, Director of the Fish and Wildlife Service, said "The Service has lost one of its most able young executives and key administrators. . . . His service has been of outstanding merit." To those of us who were fortunate enough to know John well, the words of Director Day need no amplification. To us the world has been a better place because of him and our close association with him.

I first met John Pearce in 1937 when he was in New Haven and when we were both interested in forest-game relationships on eastern Maine timberlands. My association with him progressed from cooperator to subordinate (when I served as his assistant at the Maine Unit), and finally to friend, hunting companion, and confidant.

In this paper I shall touch only briefly on his formal biography. Rather I shall discuss a few of the highlights of his career and reminisce, in a rambling fashion, on John as an individual. I would like, if possible, to pass on to others something of his philosophy as I picked it up bit by bit, through many trips with him when informal conversation lasted far into the night, and through the regular—and sometimes voluminous—correspondence which we maintained between visits.

He was born in Manchester, England on May 16, 1908, the oldest of eight children. His father was a tool maker, possessed of inventive abilities, courage, and vision. He brought his family to the United States in 1911 and became associated with the Savage Arms Corporation. The family lived in Rhode Island for a short while, then settled for a long period in upper New York where the elder Pearce advanced rapidly in experimental gun-making and ballistics. An ardent hunter and fisherman, he fully appreciated the opportunities for pursuing these sports in this country which were largely denied to all but the wealthy in the England of his youth. He made it plain to his four sons that this opportunity demanded wise use and fair play.

John's high school days saw his interest in biology constantly growing. He earned spending money and started saving a little for college by trapping muskrats and minks in the nearby marshes—running his trap lines at daybreak in order not to interfere with school. For relaxation he hunted and fished whenever possible with his father and brothers.

The demands on the resources of a large family did not permit him to attend college immediately so he took

a one-year course at the New York Ranger School at Wanakena and was graduated in the Spring of 1927. He obtained a job with the International Paper Company and spent the next two years cruising timber in the near-wilderness country of Quebec and New Brunswick.

The two-year period as a woodsman was undoubtedly a highlight in his career. In fact, I consider that it was one of the two climaxes of his professional life. He learned about "practical" forest management and he saw wild game in abundance—and he did not approve of man's treatment of either. He saw forest resources being used selfishly and with little or no thought for the future regeneration of the timber. He saw spruce grouse and ruffed grouse snared as a pastime and moose killed out of proportion to camp needs. The practical nature of his mind, which was always to temper his decisions, enabled him to realize that in woods operations far from settlements wild meat is often a necessity. It was present in abundance and was needed at periods other than the hunting season. This he condoned. But he did not condone the out-of-season slaughter for sport and the wasting of meat. This waste, both of timber and of game, and the adverse effects of large scale forest management on wildlife instilled the conservation idea very firmly in him. Coming on top of his boyhood home training and experience it whetted his appetite to do something about it.

In the fall of 1930 he entered Syracuse University, majoring in forestry and minoring in zoology. He worked part of his way doing janitor work, waiting on tables, and performing various odd jobs. He was graduated with honors in 1934. The following year he was awarded a fellowship by the University and obtained an M. S. degree in silviculture in 1935.

That spring he was appointed junior biologist with the U. S. Forest Service, with headquarters at Warren, Pa. Most of his work was on forest-game species, particularly white-tailed deer and ruffed grouse. The economic relationships of deer were an important part of his investigations and he continued his earlier studies on what was to prove one of his principal research contributions—identification of mammal browsing and feeding upon woody plants.

In the spring of 1937 he transferred from the Forest Service to the Fish and Wildlife Service and was appointed to take charge of the Forest-game Wildlife Station at New Haven, Connecticut. He held this position until the summer of 1940, conducting intensive research on the white-tailed deer, ruffed grouse, and ring-necked pheasant. The relationship of lumbering and pulp operations to wildlife was a particularly important study which he carried out at that time.

In July 1940, he was promoted and transferred to Orono, Maine as leader of the Cooperative Wildlife Research Unit at the University of Maine. It was this assignment which I consider the second climax in his career. I deem it important for several reasons. It enabled him to participate in and to supervise a wide diversity of wildlife research projects. It clinched the feeling which had been growing on him for several years that he wished to go into the administrative phase of the wildlife field. It gave him his first opportunity to direct the activities of advanced graduate students and professionally trained wildlife people. His strongest

personal interest in the field shifted, during this period, from mammalogy to ornithology. It should also be mentioned that he became a dyed-in-the-wool duck hunter! This last may seem facetious, but it is not. It influenced his later work tremendously. He always gave me the credit—or the blame (for he asserted duck hunting was a disease that once acquired became a life-long obsession for which there was no relief except more hunting) for his duck hunting endeavors. Be this as it may, there is no doubt in my mind of the effect that duck hunting had on his later administrative duties as Regional Director of the Fish and Wildlife Service. Like everything else that he did, he took this sport very seriously once he became addicted to it. He studied it as deeply as possible, both in the field and through the literature. He gained an unusual insight into the hunter's viewpoint so that he was afterwards able to deal with state game officials and sportsmen of the Northeast more effectively than any individual I have ever seen. Knowing of his own keen interest in the sport, the duck hunting fraternity (notorious for its stubbornness) had confidence in him. When, in the duck depression of a few years past, it became necessary progressively to curtail hunting privileges, John Pearce was the Government's top salesman in this region. He literally made the gunners accept drastic curtailment and "like it." As one hardboiled state game official said to me, "I can see no evidence of a scarcity of ducks in New England. If any other man told me so I wouldn't believe it, but when John Pearce says so I figure there must be, and I'll cooperate." That viewpoint was shared by many. In fact the present very favorable relations existing between most of the northeastern states and the Federal government on migratory game regulations can be attributed in a large measure to John's success in dealing with state administrators and the public. He was always honest with them and he believed in making available to them the research findings. If waterfowl and woodcock were decreased he wanted the public to know specifically where and how much, and how particular restrictions would help. But by the same token he believed the public should have full details of any increases; also that relaxation of restrictions should be made in favorable years.

Although John's tenure in Maine lasted less than two years, it constituted one of the most pleasant periods of his life. The work was agreeable, among professional people of varied interests, and the small size of the University of Maine permitted an air of informality not possible at a larger institution. The research program at the Maine Unit was then emphasizing studies on deer, woodcock, and waterfowl, all projects in which John became deeply interested. On our numerous field trips and hunting trips together, I came to know him intimately and even at that early date realized that he had capabilities far beyond those of most field biologists.

When, during the late winter of 1942, he had an opportunity for a promotion to the Regional Office in Boston he was loath to leave Maine. But his determination to make wildlife administration his life work was too firmly entrenched to be turned aside.

For three years he served as Federal Aid Inspector in the northeastern region. His administrative ability was demonstrated time after time during

the trying war period when the Pittman-Robertson program was developing toward maturity under decidedly adverse conditions.

Early in 1945 he was promoted to Assistant Regional Director. His most important assignment was in handling, as far as the Boston office was concerned, the Government's case in the fight to retain its Parker River Refuge in Essex County, Massachusetts. Local groups were then initiating steps to abolish the most important parts of the Refuge. The controversy, which eventually was to attract the attention of the Nation, went from local to Congressional scope. The issue itself was of considerable importance for a precedent was at stake, which, if lost by the Fish and Wildlife Service, could seriously affect its important National refuge chain.

In January 1946, he was promoted again, this time to Regional Director. The expanding post-war conservation movement was demanding exceptional effort from all administrators, especially with the stepped-up Federal Aid and River Basin programs. How John had the energy to streamline these new activities, cement State-Federal relationships in the efficient manner with which he did, reorganize the Service's hatchery system in this region, and coordinate various activities of overlapping divisions and non-Service organizations, has been the wonder of those who knew what was taking place. Moreover he accomplished these in the face of a slow but gradual breakdown in health. On top of all this the Parker River battle became an almost full-time job in itself. It was an endless round of speaking engagements at civic and sportsmen's groups, of press releases, of radio talks, of interviews and discussions with officials of conservation organizations outside the Fish and Wildlife Service, of appearances before legislative, gubernatorial, and finally Congressional groups. That the essential portion of Parker River was eventually saved by the Government is a tribute to the united effort of a large number of organizations and individuals. But in the opinion of many, John Pearce deserves the lion's share of the credit.

Throughout his busy period as Regional Director, he found time for occasional outings and brief vacations with his family; also for his duck hunting trips, generally with me in Maine. These brief periods of respite enabled him to keep up his administrative pace to a point far beyond belief. For John rested and relaxed as thoroughly as he tackled the problems of his office. He was devoted to his family and preferred spending his "off duty" time with them. His suburban home in Natick was a source of pride to him and he enjoyed making alterations on it and gardening.

His tenure as Regional Director was high-lighted by many things besides a successful settlement of the Parker River controversy, but that was typical of his remarkable abilities. His successes were undoubtedly due to a combination of extreme loyalty to the Fish and Wildlife Service; an unending drive for work and an energy that overcame even the ravages of cancer for many months beyond the usual breaking point; honesty that amounted almost to a passion; and a mind that was both keenly analytical and very adaptable. He could grasp the essential features of technical reports at a single reading, and on such widely diverse subjects as waterfowl management or fish food in hatcheries. He could switch his thinking abruptly

from one to another and discuss each intelligently.

Those who worked under him loved him. During his stay at the Maine Unit, where, as his assistant, I had the chance to observe his work constantly, it was apparent that he directed by leading and by inspiring—not by driving. From talking with many of his subordinates in Boston I gather that he did the same there. He made us want to give the best service we could, merely by setting the example. He rarely issued a direct order but a request or even a suggestion from him amounted to an order that one willingly carried out if possible. One of his clerks once remarked to me: "It is impossible to work *for* John Pearce. We work *with* him." That was a most apt observation.

Another major factor in his dealing with those under him was the close personal contacts he had with each, and in their problems—professional or personal. He was kindly, considerate, helpful, and—perhaps most important of all—interested in what they were doing. And it was not a forced interest; it was genuine. There was not a field station, a game management office, or a fish hatchery in the region that John did not personally visit. His inspections were not made with a view of criticism but with the earnest desire to help the man in charge.

Successful as he was at administration, I believe that his greatest contribution to the wildlife profession was as a teacher. He never taught a formal class in his life, yet his influence in molding the lives and careers of graduate students and young wildlife technicians during the past decade has been outstanding. All who have been in contact with him have profited—some in large measure. There are many young men in the profession today, holding important positions in State and Federal conservation agencies, who owe those positions to the interest which John Pearce took in them personally. On field trips, inspection trips, or at game conferences, wildlife technicians came to him with their problems, and the hour was never too late for him to give assistance. The number of reports and manuscripts which he read for his friends and acquaintances was tremendous, and the time "after hours" which he devoted to these accounts, in a large measure, for the comparative paucity of his own publications. He was just too busy helping others to do his own writing.

His indirect influence as a teacher in shaping the policies of the Wildlife Society, particularly in "behind the scene" duties, was noteworthy and the Society benefitted much by his efforts. He believed in the Society in its early and crucial days and he worked hard for it. At the time of his death he was chairman of the committee on constitutional revision.

His writings were not extensive. He imparted much to wildlife management but it was mostly verbal—in group meetings or informal discussions. He believed in basic research and considered it the very foundation for management. Yet he could be the first to differentiate between pure science and practical research. He believed in thoroughness in research, yet he knew where the degree of thoroughness should leave off, wherein lay the danger of a capable and energetic investigator going too far in following a single lead and becoming wrapped up in minute, picayune details which, though of interest zoologically, had little practical application in wildlife management.

Wildlife research, then, to him had to start with basic fundamentals, but it must proceed on practical lines. He had no patience with hasty, careless research studies, and with conclusions or recommendations based on insufficient data. Preliminary reports belonged in an organization's files—not in print, according to John.

Such publications as he put out consisted largely of notes in the various technical journals. His longer and more important writings included his Master's thesis—published in 1937 as a Roosevelt Wildlife Bulletin and entitled, "The Effect of Deer Browsing on Certain Adirondack Forest Types." Some others are: "Cooperative Wildlife Research in Practice" published in 1941 by the New York Ranger School; a lengthy paper on the identification of mammalian damage to woody plants, published in 1947 as a bulletin of the Fish and Wildlife Service; an article on mergansers entitled "Our Problem Duck" which was published in the November, 1944 issue of Outdoors with Lee Wulff as co-author; and his contribution on the northeastern region to the ring-necked pheasant book published in 1945 by the Wildlife Management Institute. In this latter, an excellent example is seen of his keen analysis as well as his practical nature.

Two manuscripts were in partial rough-draft stage at the time of his death and these, if completed, would undoubtedly have been of outstanding importance in the profession. One dealt with his experiences, observations, and philosophy of his Canadian timber cruising days. The other was a very ambitious undertaking and was to be a textbook of wildlife administration. I had discussed these publications with him at some length and had seen fragments of the preliminary manuscripts. I am sure that both publications would have been major contributions.

By the spring of 1948, John's physical deterioration had reached the stage where it was noticeable to those who knew him well. Recurrent illnesses, even though of brief duration, came more frequently, yet he continued his usual pace with only slight abatement, and his mental facilities were sharper than ever. In May he spent several days in the field with me in eastern Maine, and he confessed—for the first time—that he was concerned by his lack of physical stamina and said he had resolved to do more resting and hunting from then on. In mid-summer he took a brief vacation, spending it with his family at Cape Cod. But he returned to work without the usual zest that holidays—however brief—had always given him. Shortly afterwards he entered the hospital for a check-up, but the correct diagnosis was not forthcoming. In early September he came to Maine for a field trip and a meeting of law enforcement officials. It was his last trip and his last official task not conducted from bed. Merwin Marston, present Assistant Federal Aid Inspector in the Boston Office, and I accompanied him on the field trip. Even then, suffering considerable pain by spells, he was still the keen-minded, considerate and efficient administrator of old, and neither Marston nor I had the slightest conception that the fatal illness was to strike in a matter of only hours. The next day he was in acute physical pain, yet he wrote in my Mother's guest book, as he left for home, "chicken and duck for lunch." The meal consisted of chicken; the conversation was on the forthcoming duck hunting season. His sense of humor still prevailed.

This same sense of humor was manifest many times during the seven months that followed. They were seven months spent on hospital operating tables and in his home, gradually weakening and failing. The disease was diagnosed at last—but too late. Physical pain was not great, thanks to new and greatly improved drugs. But no drugs could dull his brain and he remained alert to the end. On my final visit to him, a few weeks before his death, he was cheerful, and as concerned about professional matters as ever. He was greatly interested in the paper I was preparing for delivery at the Washington Wildlife Conference. We discussed it at length and I left a copy with him. Shortly after my return to Maine, his formal criticism arrived. It was dictated, for by this time he could not write, but it was the same able analysis that he would have made a year before. The paper, as finally delivered, was well received but largely because I had revised it in conformity with his suggestions. Right to the end the ability to grasp essentials, eliminate "deadwood," and note omissions remained.

John Pearce is gone. Why a brilliant career should be cut short even as it was hardly begun is an unexplained mystery of life. I do not like to think of him as dead, for I still find it a fact hard to realize. Rather, I like to recall the words of one of the Fish and Wildlife Service's oldest game wardens. In a recent letter to me he wrote, not of death, but merely these words: "our good friend John has completed his work and moved on."

FISH DISTRIBUTION STUDIES, NIANGUA ARM OF THE LAKE OF THE OZARKS, MISSOURI[1]

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The present study of vertical distribution of fishes in the Niangua Arm of the Lake of the Ozarks is based on records of gill net catches and limnological observations made during the period from June 10 to September 6, 1947.

Previous studies of deep reservoirs have indicated that density currents (Wiebe, 1941) and temperature (Dendy, 1945) are important factors influencing fish distribution. Unlike these earlier studies which were concerned chiefly with the distribution of fishes in deep

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating. This study has been made possible through extensive aid of the Missouri Conservation Commission including equipment and field assistance. Special thanks are due Dr. Robert S. Campbell of the University of Missouri, Dr. George B. Herndon of the Missouri Conservation Commission, Carolyn E. Borges and all others who gave time and effort to make this study possible.

waters, this study was made in a comparatively shallow headwater. It is shown that density currents as described by Wiebe (1939) are not conspicuous, but that the headwaters of the Niangua Arm are influenced by a cold, highly oxygenated spring-water density current. In contrast with the findings of Dendy (1945), it was found that oxygen depletion overshadowed the effect of temperature as a factor influencing fish distribution. In addition, observations are presented to contribute to the limited information on the biology of the white bass.

DESCRIPTION

The Lake of the Ozarks was created by the construction of Bagnell Dam as a source of hydro-electric power on the Osage River in 1931. This dam is one-half mile long and rises 130 feet above the average elevation of the river bed. At full reservoir the gates draw water from 30 feet below the surface. The gates are about 45 feet deep, extending to within 55 feet of the river bed. The reservoir has a watershed of 14,000 square miles, and when full (660 feet above sea level) covers an area of 93 square miles. The Osage River waters are turbid almost the year round, with turbidity readings often exceeding 200 ppm at the mouth of the Niangua Arm.

About 30 miles upstream from the dam, the Niangua Arm joins the larger Osage Arm (Fig. 1). The upper half of the Niangua Arm is well protected by wooded hills and steep bluffs, and the water is relatively shallow having a maximum depth of about 45 feet. The turbidity of the water rarely exceeds 30 ppm during the summer months. As a result of more severe wave action the lower half of the Niangua Arm is usually more turbid.

The Niangua River above the level of the Lake of the Ozarks maintains an average discharge of 500 c.f.s. Throughout the summer a large portion of its discharge is spring water. Ha-Ha-Tonka Spring, located on the upper part of the Niangua Arm (Fig. 1), is

FIG. 1

believed to have a mean discharge of about 70 c.f.s. during the summer. This spring-water flows from beneath the foot of a bluff several feet above the lake level, and after passing through its own short run, enters the lake. Its course through the Niangua Arm of the lake is described below.

METHODS

Six stations were selected in regions known for good fishing on the upper half of the Niangua Arm. Figure 1

identifies these stations with the letters A to F inclusive.

Fishing operations were conducted at each station with gill nets set on the bottom perpendicular to the shore-line. In all cases each net reached from the existing shore-line to the bottom of the old river channel. They were set parallel to each other and spaced at a minimum of 75 feet apart, with the nets of larger mesh placed on the upstream and downstream sides with the smaller meshed nets centered between them. The gill nets were 300 feet long and of ¾, 1, 1½, and 2 inch mesh, bar measure.

The nets were usually examined twice daily. Measurements of fishes were classified so that a fork length of 5 inches or more, but not 6 inches, was placed in the 5 inch length class. Thus the midpoint of this length class was 5½ inches.

Information to supplement observations from gill net fishing was obtained from hoop net catches, poisoning and creel censuses.

The techniques used in the limnological phases of this project were based on methods described by Ellis, Westfall, and Ellis (1946). All pH determinations were made with a Hellige pocket comparator. Weekly temperature series were secured with a Foxborro Resistance Thermometer at each station fished, and at check points ¼ to 1 mile above and below each station. Oxygen, normal carbonate, bicarbonate, free CO_2, pH, and turbidity determinations were made at the same locations. These physico-chemical series were supplemented by determinations made in the Niangua Arm above Ha-Ha-Tonka, at Ha-Ha-Tonka Cove, in the lower Niangua Arm and in the Osage Arm of the Lake.

PHYSICAL AND CHEMICAL OBSERVATIONS

Oxygen and Temperature

An understanding of the physico-chemical picture of summer conditions in the upper portion of the Niangua Arm is essential for an interpretation of the pattern of distribution of the fishes. Since Ha-Ha-Tonka Spring assumes an important role in this picture, the course of that spring-water down the lake will be discussed in detail.

During winter and early spring of 1947, oxygen and temperature conditions of the lake were uniform at all depths. Stations G, D, and C (Fig. 1) were visited December 29, 1946, March 29, and May 3, 1947, respectively. Uniform temperatures from surface to bottom characterized each physico-chemical series, although an increase in temperature of about 8°C had occurred at all depths by May 3. Dissolved oxygen content (hereinafter referred to as D.O.) varied little with increasing depth showning no indication of subsequent conditions.

In early summer, uniform temperatures were still found 3 miles above Ha-Ha-Tonka Spring at the upper limits of the Niangua Arm, but approximately 2 miles below this point at station A, thermal stratification occurred with an associated decrease in D.O. toward the bottom (Fig. 2).

The stratification pattern, described at station A was highly modified at Ha-Ha-Tonka Spring as a result of the entrance of cold water. Figure 3 illustrates conditions at the point of juncture between spring-water and lake water. This cold well-aerated water enters the lake, settles and flows along the bottom of the river channel as a

density current. The temperature gradient is extremely steep at the interface of the cold and warm water. The D.O. of the denser water exceeds that of the surface water.

The graphs which follow illustrate the oxygen and temperature conditions of this denser water as it progresses down the lake. These graphs were selected from a series of profiles taken from June to late July before the onset of the lake's most intense stagnation. They are designated as a pre-stagnation series.

Pre-stagnation. Figures 4 and 5 show that the spring-water warmed gradually and that its D.O. decreased until finally at station E, 8 miles below Ha-Ha-Tonka, it approached the point where it no longer was recognizable. However, it is important to note here, that in every determination upstream from station F, the minimal D.O. was in excess of 4 ppm.

Observations at station G, during this period, offered no definite evidence that the spring-water maintained its identity in the lower section of the Niangua Arm.

Stagnation. By late July, summer stagnation conditions were evident in the Niangua Arm. Although the identity of spring-water flowing on the bottom of the channel was maintained by temperature differences, D.O. profiles presented a new picture (Figs. 6 and 7). From station C, lying 3 miles below the spring through station E, five miles below the spring, there was a pronounced D.O. deficiency in a wide stratum immediately above the interface of the cold and warm water.

Since there were no rains in the Niangua watershed within 30 days preceding the observations, and since there was no visible evidence of abnormal turbidity in the stagnant stratum, it is believed that the D.O. deficiency was due entirely to normal biological and chemical use of the oxygen. The only unusual factor was believed to be the cold well-aerated density current maintaining a higher D.O. near the bottom.

At station F, eight miles below the spring, the identity of the spring-water was doubtful. Even though temperature readings indicated the possibility that this cold water still maintained its identity on the bottom, it appeared as though the D.O. had dropped sufficiently to make it difficult to identify the spring-water by oxygen determination alone.

Eleven miles below the source of the spring, there was no longer chemical or physical evidence that spring-water maintained its identity. Muddy waters of the Osage Arm were usually in evidence at this station. Extremely low D.O. readings were characteristic of the bottom stratum making the waters unsuitable for fishes.

Post-stagnation. In early September the bottom stratum of spring-water could still be identified by temperature readings, and its D.O. did not vary greatly from August conditions, but a change had occurred in the stagnant layer above the spring-water.

At this time the D.O. was increasing in the formerly stagnant levels of the upper part of the Niangua Arm (Figs. 8 and 9). The D.O. profile at station C, where there had been a pronounced oxygen-deficient middle layer, was now more nearly uniform, and at stations D and E the oxygen-deficient stratum seemed to be narrowing. At both stations the minimal D.O. readings were higher than the minimal D.O. readings

of August. This sudden increase in D.O. did not seem to be a result of fall overturn (Fig. 8), especially since there had been no significant changes in the weather. It could not be attributed to the effects of increased inflow, because there had been no rainfall other than 2 or 3 light showers on the Niangua watershed since July. However, the rate of drawdown had changed.

The water level had been held nearly at full reservoir through the month of June. In July and early August a gradual drawdown became noticeable, probably not exceeding 3 feet in 45 days. Then in the latter part of August the lake dropped an additional 4 feet in 15 days.

It is proposed that this pre-overturn increase in D.O. on the upper Niangua Arm was due to the drawdown just described, and to the flow of cold springwater along the bottom. This well-aerated water displaced a bottom stratum which probably would have been deficient in D.O. The effects of drawdown were two-fold. First, the loss of an additional 4 feet of water appreciably shallowed the upper portion of the Niangua Arm (stations C, D and E) making this arm of the lake less susceptible to continued stagnation. Second, as recognized by Wiebe (1939) in Norris Reservoir, the increased drawdown caused a downstream movement of much of the denser water stagnated in the upper reaches of this arm. This August profile moved farther down the lake and the oxygen-deficient waters were finally replaced by well-aerated water.

On September 6, the summer study of the Lake of the Ozarks was concluded. It was not until October 11, that further observations were made. During the 35 days intervening between September 6 and October 11, the lake was drawn down an additional 3 to 4 feet, and it is believed that these factors may have aided in extending waters high in D.O. down the Niangua Arm before the onset of fall overturn. This suggestion cannot be verified because appreciable wave action had already begun by October 11.

Except for downstream movement of water in September, density currents, as described by Wiebe (1939) were not a conspicuous feature of the headwater area. However, evidence was gathered which suggested that density currents did appear in the lower Niangua Arm during the summer. These currents were identified in some cases by oxygen deficiency and in other instances by turbidity and differences in the concentrations of hydrogen ion and bicarbonate.

Observations on the Osage Arm (the main reservoir) were limited in nature, but indicated that oxygen levels were not now as low in these waters as they had been previously reported (Weyer, 1940). At the mouth of the Niangua Arm, on July 29, turbidity was high (250 ppm) and D.O. dropped from 6.5 ppm at the surface to 3 ppm at 35 feet and to 0.2 ppm at the

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FIGS. 2–9.—Representative dissolved oxygen and temperature profiles selected from a series of 100 profiles recorded during the summer of 1947. D.O. is represented by a broken line, while temperature in degrees centigrade is shown by the solid line.

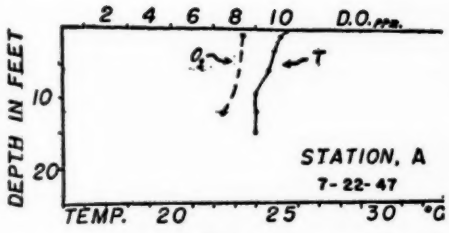

FIG. 2

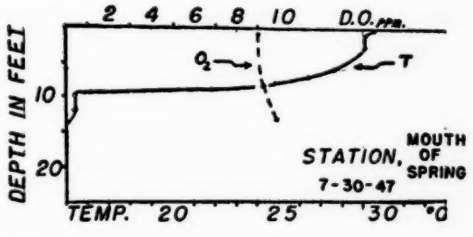

FIG. 3

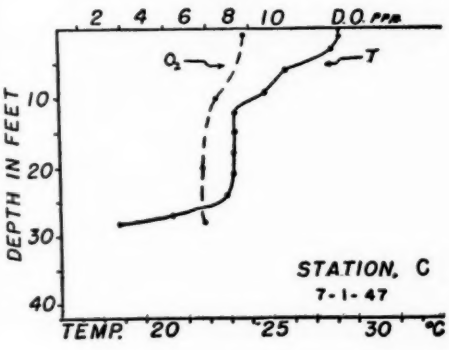

FIG. 4

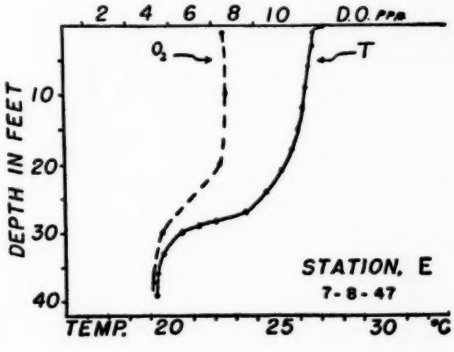

FIG. 5

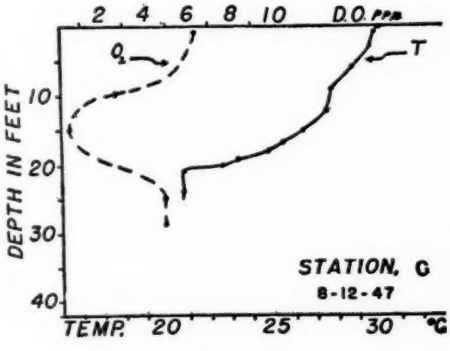

FIG. 6

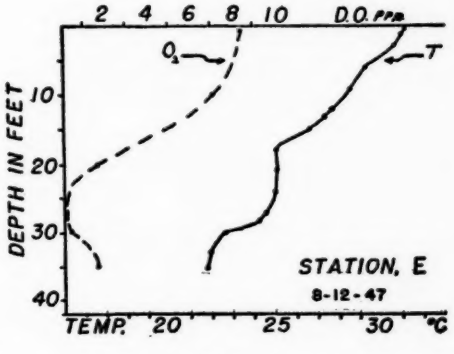

FIG. 7

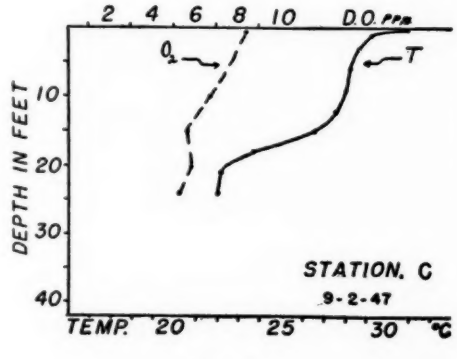

FIG. 8

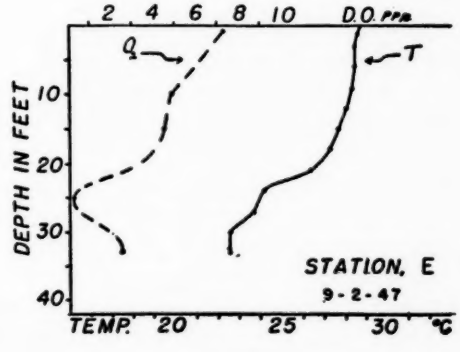

FIG. 9

bottom (90 feet). At Bagnell Dam turbidity was less than half this amount (110 ppm) and D.O. did not fall below 3 ppm until the 70 foot depth was reached. Since apparently much of the silt load is dropped before the waters of the Osage reached Bagnell Dam, the D.O. would be expected to be somewhat higher at the dam.

Other Physico-Chemical Factors

Other physico-chemical factors observed included free CO_2, pH, carbonates, and turbidity.

During winter and spring the free CO_2 content was uniformly low (4 ppm) and the pH remained near 7.8. Throughout the summer free CO_2 was absent from surface waters, but present in fairly high concentration in the deeper waters (10 to 16 ppm), while the pH ranged from 7.8 at the surface to 7.1 at the bottom in the deepest portion of the arm.

The waters of the Niangua Arm are hard, with a midsummer bicarbonate content ranging from 80 ppm in the turbid waters of the lower reaches to over 160 ppm immediately below Ha-Ha-Tonka Spring. In most cases during summer there was an increase in bicarbonate content from surface to bottom throughout this arm of the reservoir. At Ha-Ha-Tonka Spring normal carbonates were absent and bicarbonates were in excess of 200 ppm while the free CO_2 content was 12 ppm and the pH was 7.2.

Changes in turbidity caused by inflowing water and wind action on the Niangua Arm seemed to follow a definite pattern during the summer. The water just below station D was generally the least turbid in the Arm (10 to 15 ppm). Turbidity usually increased progressively upstream and downstream from that point, varying with the amount of rainfall in the Niangua, Little Niangua and Osage watersheds.

The significance of some of the foregoing features to fish distribution are discussed below. The current of springwater flowing along the bottom of the reservoir, the presence of a stagnant middle stratum during part of the summer, and the pre-overturn increase in D.O. on the upper Niangua Arm were unusual conditions which might be expected to lead to unusual departures from depth distribution patterns of fishes as recorded in other bodies of water.

DISTRIBUTION OF FISHES[1]

From June 13 to September 4, 1947, a total of 225 gill net days of fishing in the Niangua Arm yielded 2,256 fishes of 23 species (Table 1). Twenty-four hours of fishing with 1 gill net (6 ft. by 300 ft.) including 2 runs for removal of fishes was considered 1 net day. On the basis of this standard, the average number of fishes caught per net day was 10.03.

It should be noted that neither gill netting nor poisoning are believed to show a true sample of the rough fish population. Rough fish control operations revealed these species, particularly carp, to be more abundant than is shown here.

The depth distribution of these fishes, as shown in Figures 10 to 13, followed 3 general patterns. During June, fishes were fairly evenly distributed from sur-

[1] Terminology follows *A list of common and scientific names of the better known fishes of the United States and Canada*. Spec. Pub. No. 1, Amer. Fish. Soc., 1948.

face to bottom. In late July and August most species avoided the middle stagnant levels in the upper Niangua Arm, concentrating above and below the stagnant water (Fig. 12, C and D). Finally, in September, the fishes reentered the middle levels, but concentrated in the deepest waters (Fig. 13, C). These patterns of distribution will be discussed in detail by species for all stations except A and B. Since fish distribution at stations A and B was not subject to the limitations of lowered D.O. the distribution at these stations is discussed separately.

Fishing operations were conducted at station A during July to compare the shallow water catch at the head of the reservoir with the take in deeper waters. The species composition and frequency of occurrence were found to be much the same as in the lower sections of the lake, therefore this station was not revisited.

A familiarity with the pattern of distribution of the fishes at station B is essential to an understanding of the distribution of fishes in the Niangua Arm. Station B, lying just below Ha-Ha-Tonka, was unique in that it did not show severe stagnation at any time, and as a result it showed an unusual midsummer concentration of fishes. During June, freshwater drum dominated the catch from this region, but in late July and August almost all species occurred much more frequently in the catch. Some of the fishes, such as white bass, yellow pikeperch, and freshwater drum, exhibited a marked preference for the cold bottom stratum of spring-water (Fig. 13, B). It is be-

TABLE 1.—CATCH OF FISHES, BY SPECIES, TAKEN IN GILL NETS, NIANGUA ARM, LAKE OF THE OZARKS, 1947

	No. Caught	Per Cent of Total No.
White crappie (*Pomoxis annularis*)	716	31.74
Freshwater drum (*Aplodinotus grunniens*)	420	18.62
Gizzard shad (*Dorosoma cepedianum*)	195	8.64
Carpsuckers (*Carpiodes* spp.)	164	7.27
White bass (*Lepibema chrysops*)	150	6.65
Goldeye (*Amphiodon alosoides*)	131	5.81
Channel catfish (*Ictalurus lacustris punctatus*)	113	5.01
Redhorse (*Moxostoma* spp.)	90	3.99
Longnose gar (*Lepisosteus osseus*)	81	3.59
Yellow pikeperch (*Stizostedion v. vitreum*)	60	2.66
Green sunfish (*Lepomis cyanellus*)	25	1.11
Smallmouth buffalo (*Ictiobus bubalis*)	23	1.02
Mooneye (*Hiodon tergisus*)	16	0.70
Carp (*Cyprinus carpio*)	15	0.66
Paddlefish (*Polyodon spathula*)	14	0.62
Longear sunfish (*Lepomis m. megalotis*)	9	0.40
Bluegill (*Lepomis macrochirus*)	9	0.40
Largemouth black bass (*Micropterus salmoides*)	7	0.31
Orange spotted sunfish (*Lepomis humilis*)	5	0.22
Smallmouth black bass (*Micropterus dolomieu*)	4	0.18
Blue catfish (*Ictalurus f. furcatus*)	4	0.18
Flathead catfish (*Pilodictus olivaris*)	4	0.18
Black buffalo (*Ictiobus niger*)	1	0.04
	2,256	100.00%

lieved that this increase in catch, amounting to about 3 times as many fishes per net day, may indicate a migration into the spring area. With a decrease in D.O. at downstream stations, most of these fishes are believed either to have followed the temperature and D.O. gradient to the mouth of the spring, or to have moved into that region in pursuit of forage fishes which the bottom near the mouth of Ha-Ha-Tonka Spring.

In September a downstream movement of fishes from Ha-Ha-Tonka was correlated with an increase in D.O. at the lower stations. When angling success declined at Ha-Ha-Tonka, the catch per gill net day reached its highest peak of the summer down reservoir at station C. Thus the split distribution

TABLE 2.—FISHES COLLECTED DURING THE FIRST 24 HOURS[2] FOLLOWING POISONING OF A ONE ACRE BAY, NIANGUA ARM OF THE LAKE OF THE OZARKS, JULY 9, 1947[3]

	Number Taken	Weight in Lbs.	Per Cent by Weight
Channel catfish	175	46.20	52.50
Gizzard shad	224	12.55	14.25
Freshwater drum	107	9.10	10.35
Largemouth buffalo	3	4.55	5.15
Largemouth black bass	94	2.65	3.00
Bluegill	85	2.55	2.90
White bass	8	2.35	2.65
Green sunfish	68	1.90	2.15
Smallmouth buffalo	1	1.50	1.70
Carpsuckers	3	1.30	1.50
Yellow pikeperch	2	0.80	0.90
Mooneye	3	0.75	0.85
Carp	16	0.50	0.60
Other fishes[1]	88	1.30	1.50
	877	88.00	100.00

[1] Orange spotted sunfish, redhorse, logperch, bluntnose minnow, spotted black bass, stoneroller, brook silverside, emerald shiner, Ozark studfish, blackstripe topminnow, goldeye.
[2] During the second 24 hours an additional 100 pounds of fishes were collected, with channel catfish, goldeye, shad and drum predominating in that order.
[3] Maximum depth 6 feet, water temperature 27°C.

may have reacted to the temperature and D.O. gradients. Supporting evidence for this contention was secured on July 31, and August 1, when 3 gill nets were set at the mouth of Ha-Ha-Tonka Spring. More white bass, gizzard shad and redhorse were taken per net day than at any station previously visited. Thus the evidence from these catches confirmed the judgment of guides who had been successfully advising their parties to fish for white bass on of August (Fig. 12, C) was replaced by a concentration of fishes near the bottom (Fig. 13, C).

Observations on the trend of hoop net catches supported the preceding explanation. During June, fishes were taken in hoop nets at all depths in the upper half of the arm. In mid-summer, fishes were caught almost exclusively near station B, and in September, hoop nets began to take more fishes down reservoir near station C.

There is no evidence that there was a summer movement of fishes down the reservoir toward the deeper waters near the dam. Limited experimental data indicated that the absence of fishes from the middle strata during July and August was correlated with depletion of D.O. Observations were made on 1 hoop net operated in 35 feet of water at station E throughout the month of August. Another hoop net, baited and set in 9 feet of water, was used as a control. Some of the fishes caught in the shallow-water net were removed and placed in the deep-water net. Even carp were unable to survive longer than 3 days in the deep water when the D.O. was approximately 1.2 ppm, and buffalo fish and carpsuckers died within 1 to 3 days when the D.O. ranged from 1.6 to 2 ppm (temperature, 21° to 24°C). In contrast, all fishes left in the control net survived. This evidence, plus the fact that fishes were dead when taken by gill nets in the stagnant levels, suggests that most species would be unable to survive during a continued stay in the severely stagnated stratum of the reservoir.

Attempts at correlation of fish distribution with water temperature were unsuccessful. Fishes seemed to avoid the stagnant layer of water, and were therefore limited in distribution to relatively narrow strata which offered little opportunity for the exercise of temperature preference.

The results of poisoning a 1 acre bay with rotenone are given in Table 2. During the first 24 hours after poisoning the fishes were counted, weighed and measured, while during the second 24 hour period only total weights and estimates of species composition were taken. The experiment yielded 188 pounds of fishes to the acre. Since there are relatively few shallow bays of this sort on the Niangua Arm, and since the particular bay used is known as a good fishing area, this figure should not be taken as an index of standing crop. The main value of this operation was believed to be in its use as a nonselective index of species composition.

TABLE 3.—LOCATION OF FISHES IN THE TOP, MIDDLE AND LOWER THIRDS OF THE GILL NETS,[1] NIANGUA ARM, LAKE OF THE OZARKS, 1947

	Top Third	Middle Third	Bottom Third
White Crappie	323[2] *45%*	282 *39%*	111 *16%*
Freshwater Drum	160 *33%*	163 *39%*	97 *23%*
Gizzard Shad	78 *40%*	69 *35%*	48 *35%*
Carpsuckers	37 *23%*	75 *45%*	52 *32%*
White Bass	37 *25%*	71 *47%*	42 *28%*
Goldeye	60 *45%*	58 *44%*	13 *10%*
Channel Catfish	35 *31%*	46 *41%*	32 *28%*
Redhorse	12 *13%*	43 *48%*	35 *39%*
Longnose Gar	54 *67%*	23 *28%*	4 *5%*
Yellow Pikeperch	12 *20%*	28 *47%*	20 *33%*

[1] Net depth 6 feet.
[2] Upper number (323) refers to actual count of fish, while lower number (45%) represents per cent of total take for that species.

The remainder of this discussion is subdivided according to species, with notes on their ecology, and depth distribution at all stations except A and

B. Accompanying information is also given with reference to size groups and the location of fishes in the top, middle or lower thirds of the nets (Table 3).

White Crappie. According to the 1946 and 1947 creel census reports on the Lake of the Ozarks, anglers took more crappie than any other species of fish (Funk, 1947 and 1948). White crappie dominated the gill net catches during the summer of 1947.

During June and early July white crappie ranged from the surface to a depth of 28 feet with peaks of abundance at the middle of their range at depths of 8 to 16 feet. In the stagnation period of late July and August they concentrated closer to the surface, with pronounced peaks of abundance near the deeper limits of their range at depths of 8 to 12 feet. Finally in September with an increase of D.O in the former stagnant levels it appeared that crappie were once again inhabiting deeper waters.

Most of these fish were small, falling into the 4, 5 and 6 inch size classes and many were infested with fungus infection on the caudal, dorsal and anal fins. An examination of 299 white crappie netted from July 31 to September 4, showed 10.7 per cent of the fish to be diseased in the following proportion by size class: 4″—31%; 5″—16%; 6″—8%; 7″ to 12″–none.

It is believed that crowding may have accounted for the predominance of diseased fish in the small size classes. Growth rate investigations are needed for verification.

Freshwater Drum. Freshwater drum (sheepshead) were second in abundance in the gill net catch. Throughout early summer, drum ranged from the deepest waters to within 6 to 10 feet of the surface, reaching their peak of abundance within 4 to 8 feet above the bottom of the channel. With the coming of August, drum concentrated even closer to the bottom in the narrow stratum of spring-water. Unlike the white crappie, a few of these fish were usually present in the oxygen depleted strata which lay immediately above the spring-water.

Analysis of data presented in Table 3, indicates that, contrary to what might be expected, the catch of drum did not occur predominately in the lower third of the nets. Inasmuch as Barnickol (unpublished ms.) has shown that the Niangua Arm produces very little in the way of a mollusc or macrocrustacean crop, and since it is known that fishermen now frequently catch drum on minnows and plugs, it would appear that this species might have changed its feeding habits in the Lake of the Ozarks from an expected diet of molluscs and macrocrustaceans to a diet of fishes, as was found by Dendy (1946) in Norris Reservoir.

Drum most frequently netted were in the 5 to 7 inch size class, yet larger fish were commonly taken in hoop nets. Since the creel census (Funk, unpublished) showed that this species comprised less than 2 per cent of the hook and line harvest it would appear that drum might stand additional cropping.

Gizzard Shad. Gizzard shad ranked third in number in the gill net catch. During June and early July these fish were taken from all depths, while during August they were found both above and below the stagnant middle stratum but generally not in the stagnant water.

The 8 to 10 inch size classes were most numerous in the total catch, but this is believed to have been a result of

gill net selectivity. Many small shad were counted in the poisoning experiment, and repeated estimates indicated the presence of literally millions of 1 to 2 inch fish schooling at the surface of the lake from July to September.

The foregoing evidence combined with results of the poisoning experiment (where shad comprised over 14% of the total weight) is suggestive of an abundance of this species. Preliminary stomach analysis of white bass and yellow pikeperch caught by anglers during late July showed almost exclusive use of shad fry. It is apparent that gizzard shad are an important forage species in the lake.

Carpsuckers. These were species which, though distributed at all depths during early summer, showed a definite concentration near the surface during August. Experiments conducted with trapped fish in hoop nets showed that carpsuckers did not survive 48 hours in 1.3 ppm D.O. at 21°C.

Shallow water over mud bottoms resulting from inundation of old fields proved productive of carpsuckers.

White Bass. White bass share with crappie the role of most important game fish in the lake. According to creel census data (Funk, 1947 and 1948) these two species comprise 80 to 90 per cent of the anglers' take.

During early summer there were not enough white bass taken to show any particular depth preference, but in July and August this species appeared to be avoiding waters of low D.O. going no deeper than 10 to 14 feet. In September, they were found mainly near the bottom of the channel. Apparently they left the surface stratum when the D.O. increased in the deeper waters.

This species was collected in greatest numbers in the 2 inch mesh gill nets, with the 9 and the 12 inch (fork length) classes predominating.

The history of the white bass in the Niangua Arm is unusual. According to local residents this fish was rarely taken in either the Osage or the Niangua Rivers before the construction of Bagnell Dam. After construction of the dam white bass were caught more frequently, until finally, about ten years after impoundment they became a major resource for sport fishermen. Since that time guides have noticed a definite pattern of white bass movements in the Niangua Arm. During spring and early summer the fish are caught by trolling over the middle portion of the arm (station D to F). As summer progresses they are taken while schooling near the surface farther upstream, and in midsummer they are caught only on the bottom near the mouth of Ha-Ha-Tonka Spring. In 1947, the upstream movement occurred at the time of the main Mayfly hatches, June 20 to July 10, and tapered off shortly after July 7, when the first schools of small gizzard shad were observed. At the time when white bass stopped striking lures at the surface, fishermen began taking them on the bottom at the mouth of the spring. For the next 40 days white bass fishing was excellent below Ha-Ha-Tonka in the lower 2 to 4 feet of spring-water and netting showed that both white bass and gizzard shad were present in these bottom waters (Figs. 12, T, and 13, B). As the season progressed the only trend in the movements of the white bass seemed to be a gradual migration downstream from the mouth of Ha-Ha-Tonka Spring. Finally in late

August this species was being caught almost exclusively on the bottom approximately a quarter mile below station B.

Smaller fish of the 5 and 6 inch size classes dominated the catch during the last week of August. Before September 1, white bass fishing virtually ceased to exist. The take by gill nets at station C during September indicated that these fish had migrated downstream at the time of the increase in D.O. (Fig. 8).

The midsummer migration into the cool water near the bottom just below the spring are believed to be influenced by temperature preference and food supply. Both young and adult white bass seem to prefer cooler deeper waters during midsummer (Adams and Hankinson, 1928). It is believed that, with summer stagnation making the deep cool waters of the middle and lower Niangua Arm unsuitable, these fish move upstream toward Ha-Ha-Tonka Spring, possibly responding to the cold spring current of well aerated water. Stomach analysis indicated that white bass taken from the spring area were feeding almost exclusively on young gizzard shad, and since many adult shad were netted in the same region (Fig. 12, T), it is believed that there occurred a similar concentration of shad in the same waters thereby offering a food supply to the white bass. It appears as though the downstream movement was correlated with the September increase in D.O. which started below Ha-Ha-Tonka Spring during late August.

Goldeye. Goldeye are not important in the sport fishery. However this species strikes artificial lures and is frequently taken by anglers.

Goldeye showed no depth preference during June. In mid-July they were taken less frequently in the lower stratum, and from that time through August they seemed to range only from the surface to the 16-foot level. The September picture showed that goldeye gathered in deeper water.

This fish appeared to move upstream at about the same time as the white bass.

Channel Catfish. Throughout the summer this species was distributed at all depths, appearing to be more tolerant of a low D.O. than most fishes. While the pattern of distribution did not show that channel catfish avoided stagnant water, records indicated that during August the individuals taken in the deeper water were mostly small fish of the 5 to 7 inch size classes. Those taken nearer the surface at depths of 5 to 15 feet were much larger fish. This species did not show any particular affinity for the bottom.

It is believed that channel catfish could withstand greater harvesting. Not only do relatively few fishermen angle for them, but creel censuses (Funk, unpublished) reveal that they comprise only 3 per cent of the total take. This is in direct contrast to the results of poisoning where over 50 per cent of the total weight was channel catfish.

Redhorse. These species presented a distinctive pattern of distribution. Rarely taken in water deeper than 8 feet the redhorse showed little or no variation in depth distribution from June to September. They were caught in a rather evenly distributed range of size classes from 5 to 12 inches.

Longnose Gar. The longnose gar is another species which was tolerant of low D.O. From June through Septem-

ber this fish ranged from the surface to the deepest water with exception noted at only one station (Fig. 11). Only on three occasions were identifiable remains ever found in the stomachs of gar, and those revealed nothing but small gizzard shad.

Yellow Pikeperch. The yellow pikeperch (walleye or jack salmon) is probably one of the species most desired by fishermen, but least frequently caught. It is reported by reliable sources that in the first 5 years after impoundment the reservoir produced phenomenal catches. Recent creel censuses (Funk, 1947) show that only 2.8 per cent of the take is composed of yellow pikeperch.

During mid-August the yellow pikeperch seemed to prefer the bottom stratum of spring-water (Fig. 12, D), even when the D.O. was as low as 2.5 ppm. When the D.O. dropped to 1.3 ppm in the bottom stratum, yellow pikeperch moved to the surface waters (Fig. 13, E). With the September increase in D.O. at station C they returned to the cold bottom water.

Sunfishes. The bluegill, green, long-ear, and orange-spotted sunfishes are considered together because the total catch was small. Seventy-five per cent of the total were taken in the first 2 feet of surface water close to shore.

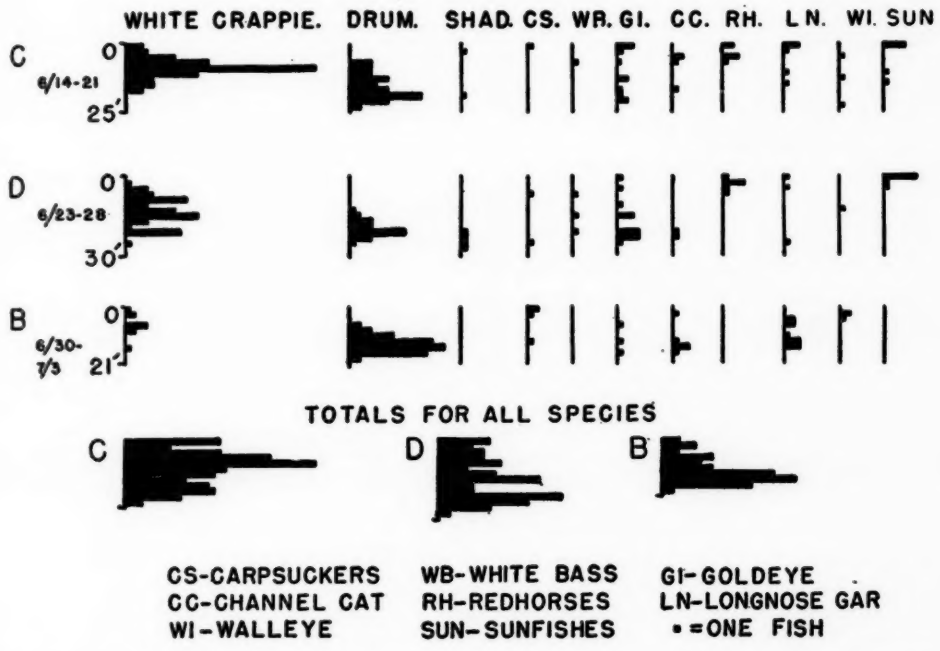

FIG. 10.—Depth distribution of species most frequently taken, graphed at two-foot intervals Stations B, C, and D during June and early July.

CONSIDERATIONS FOR MANAGEMENT

The results of the vertical distribution study are immediately applicable to management.

Specific recommendations for man-

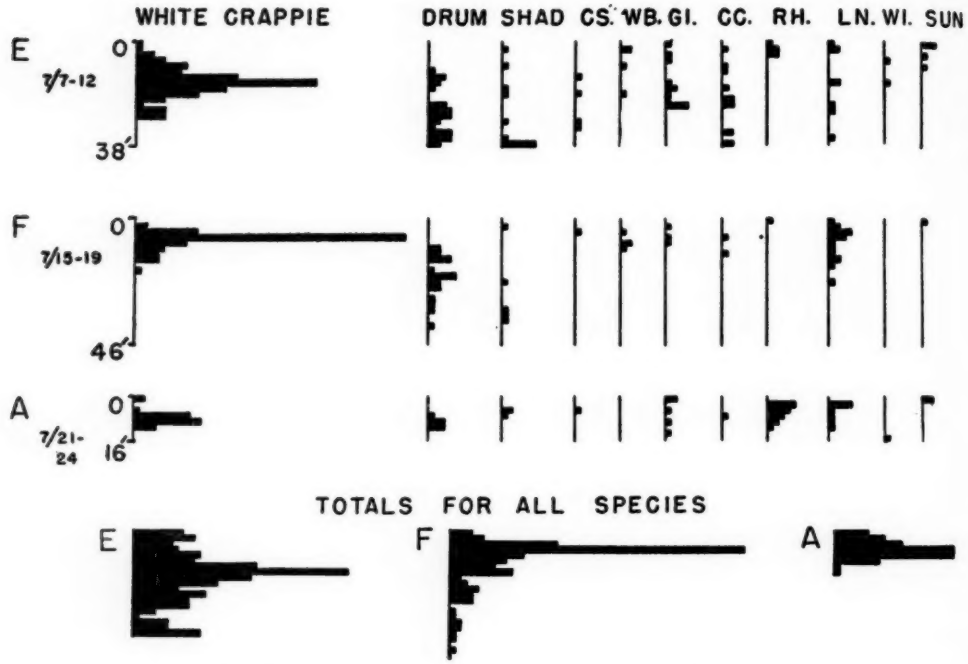

FIG. 11.—Same data as Fig. 10, for stations A, E, and F in July.

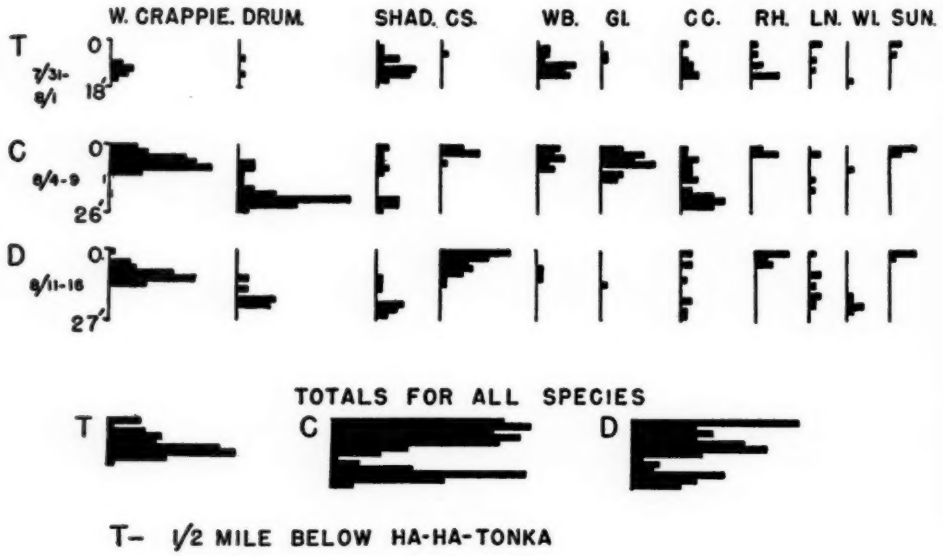

FIG. 12.—Same data as Fig. 10, for stations C, D, and T, in July and August.

agement are suggested as follows:

1. Information relative to the unusual distribution of fishes in this section of the lake should be made known to the angling public in order that they might utilize the crop more fully.

2. The quantity of channel catfishes present suggest the desirability of an increased harvest. This might be accomplished through more intensive pole and line and trotline fishing along the rocky bluffs at depths not exceeding 10 feet during the period of stagnation.

3. Additional cropping of the yellow pikeperch (walleye) may be made possible through trolling just above the channel bottom below Ha-Ha-Tonka Spring during the period of stagnation.

4. Further harvest of freshwater drum, buffalo, carp and other rough fishes should be encouraged.

Before an extensive management program can be recommended for the Lake of the Ozarks, information on harvest and growth rates of the game and pan species must be secured. The white bass and white crappie are chief among this group. Together they account for an estimated 80 per cent of the harvest as revealed by the creel census conducted during the past two years. Although the black basses have shown an appreciable decline since the early history of the reservoir, they are still significant in the creel. Some suggestions for future studies on the Lake of the Ozarks follow:

1. Growth rate studies are suggested for the black basses, the yellow pikeperch, and for white bass, white crappie and other pan fishes.

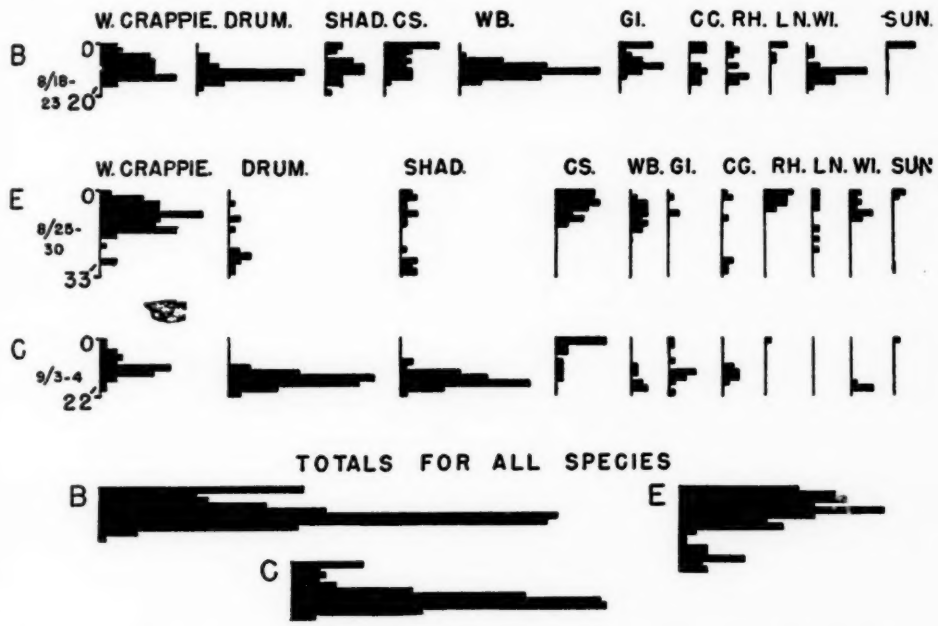

FIG. 13.—Same data as Fig. 10, for stations B, C, and E in August and September.

2. The concentration of white bass in the vicinity of Ha-Ha-Tonka offers an unusual opportunity to evaluate the extent of the harvest through tagging and creel census.

3. Similar observations of dissolved oxygen and temperature stratification as well as the study of vertical distribution of fishes as followed in this work should be extended to other sections of the lake.

SUMMARY

The present study of vertical distribution of fishes in the Niangua Arm of the Lake of the Ozarks is based on records of gill net catches and limnological observations made during the period from June 10 to September 6, 1947.

Previous studies of deep reservoirs have indicated that density currents and temperature are important factors influencing fish distribution. Unlike these earlier studies, which were concerned chiefly with the distribution of fishes in deep waters, this study was made in a comparatively shallow headwater. It is shown that density currents as described in Norris Reservoir, Tennessee, are not conspicuous, but that the headwater of the Niangua Arm is influenced by a cold, highly oxygenated spring-water density current. It was found that oxygen depletion overshadowed the effect of temperature as a factor influencing fish distribution.

During winter and spring, D.O. and temperature were uniform in the Niangua Arm. In June dissolved oxygen was present at all depths, but during July and August intense stagnation occurred. The lower half of the Niangua Arm was characterized by severe oxygen depletion in the deeper strata. The deeper waters of the upper Niangua Arm showed a somewhat similar oxygen deficiency but were modified by a bottom stratum of well aerated cold spring-water. This spring-water flowed along the bottom of the channel as a cold water density current, displacing oxygen depleted waters. This bottom current altered limnological conditions so that the resultant D.O. profile showed a layer of water low in D.O. sandwiched between 2 well aerated layers.

The depth distribution of fishes followed three general patterns which were closely correlated with the limnological conditions. During June, fishes were rather evenly distributed from surface to bottom. In late July and August most species avoided the middle stagnant levels in the upper Niangua Arm, concentrating above and below the stagnant water. Finally, in September, the fishes reentered the middle levels but concentrated in the deepest waters.

A midsummer movement of fishes, particularly white bass, up the Niangua Arm and into the cold spring-waters was observed. It is suggested that this migration may be correlated with thermal stratification and intense stagnation.

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DENNING HABITS AND HOME RANGE OF RED FOXES IN NEW YORK STATE*

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To date the most thorough and valuable work on the biology of foxes has been concerned with the food and feeding behaviour, with emphasis on their role as predators. It is apparent that a fair evaluation of the economic importance of the fox can be attained only through additional contributions to the life history of the species.

The present study was carried out in the Cayuga Lake Basin of central New York from the fall of 1946 to the summer of 1948.

Information from the banding and releasing of approximately 120 foxes supplemented field observations. Significant data were gathered on certain denning habits, seasonal population shifts, and home range. Captured animals were released shortly after trapping at the capture site.

* This paper is part of a doctoral thesis presented to the Faculty of the Cornell University Graduate School.

DEN SITES

The main entrance of a typical red fox den is usually about 15 inches high. This may distinguish it from a hole used by other eastern mammals. Rain washes dirt and leaves into the entrance once abandoned by foxes. If it is appropriated by woodchucks, as frequently occurs, the entrance hole appears smaller. Foxes keep a den opening well cleared out.

In 1926, W. J. Hamilton, Jr. dug out a fox den at McLean, New York. Situated in an open pasture, the burrow had two entrances 26 feet apart; four red fox pups estimated to be five weeks old were found in the deepest part at about four feet. Livezey and Evenden (1943) describe an Oregon red fox den having a main entrance 15 inches high and eight inches wide tapering to a five inch tunnel which extended for 47 feet. A temporary den excavated near Ithaca, New York, had one entrance and extended for 75 feet in fine sandy loam at

an average depth of three and a half feet; there were several side branches not excavated. A second temporary den dug out in rocky black loam soil connected two entrances 30 feet apart. The deepest part of the hole was a slightly enlarged chamber at four feet underground with a side branch going deeper. Dens have been dug out to a depth of 14 feet (Komarek, 1939). Kolosov (1935) has shown that soil conditions on the Caspian plain definitely affect the distribution and internal structure of dens made by the European fox (*Vulpes vulpes*) and Tartar fox (*Vulpes corsak*). He describes as rearing burrows shallow dens with many branches in clay soil and deeper dens with fewer branches in sandy soil. He also observed that 70 per cent of the dens examined were temporary retreats, the holes being shallow and short with few if any branches. Observations made in the New York area substantiate this to the extent that most fox litters are raised in large permanent dens, whereas many enlarged woodchuck burrows in open fields are temporary in nature.

Scott (1943) observed that in Iowa red foxes dug out dens in early February in preparation for spring denning. The same condition was observed in the Ithaca vicinity in the late winter of 1948. Ten dens cleared by February 17 had produced litters in the spring of 1947. Therefore, late winter or early spring tracks in snow often give clues to spring denning sites.

Occasionally it is difficult to determine if a den is occupied, particularly during March or early April before the pups come above ground. Once the young begin to come out, a used den is evident. Quantities of litter of various kinds are found about the entrance and pup droppings are distinguishable by their relatively small size. An old or abandoned den which has been used over a period of years can usually be recognized by the presence of old bones in the vicinity of the entrance. Usually a strong fox odor permeates a used den.

Of 50 den sites examined in the central New York area, all except four were confined to fine sandy soil. A hole cleared by foxes could often be spotted at some distance by a conspicuous pile of sand at the main entrance. Some large dens may have only two or three entrances whereas others may have over 20 holes which are all in use. Murie (1944) found typical dens of the Alaska red fox (*Vulpes kenaiensis*) with six to 19 entrances. Murie likewise found the majority of dens in sandy loam. Soper (1942) found Alberta foxes denning in sand ridges. This preference for sandy loam is almost universal among red foxes. Sand offers easy digging, is clean and porous, thus making an ideal "earth." After a period of den searching, it was found that the most successful method was to look over sandy areas and systematically inquire of residents the whereabouts of fox dens.

The 50 den sites inspected can be broadly classified as shown below:

Type of Land	*Number of Dens*
Open plowed field	6
Open unplowed field	14
Hedgerow	8
In woods less than 50 yards from open field	12
Deeper in woods	7
Rocks	2
Under foundation of old barn	1

Most of the dens were obviously found in the open or near fields since pups could be more readily seen, thus

indicating the presence of a den. Dens deeper in the woods may be typical but are secluded and very difficult to find. Most woods dens are old established ones which have probably been used for generations.

COMMUNAL DENNING

Seton (1929) and others have described in some detail the behaviour of fox families during the denning period. In all accounts the assumption is made that the den group is composed of one family. Murie (1944) describes some Alaska dens as being three and five miles apart, suggesting the home range of separate paired foxes. Scott (1943) cites the separation of centers of activity of individual fox families, implying territorialism and possibly intraspecific intolerance.

While unquestionably the majority of fox dens are occupied by one family, much evidence was found of intraspecific tolerance and what may even be termed as intraspecific dependence during the crucial weeks of the denning period. Two litters living in one den is not an unusual condition in central New York. Although a high population density undoubtedly makes communal denning a more common occurrence, the data collected indicate that such denning has been practised by red foxes for many years.

Communal behaviour tends to cause a concentration of fox populations in the spring and early summer months, a definite seasonal condition which should be recognized in evaluating fox predation. The evidence for such is enumerated below.

Nine is the maximum litter size recorded on ranch foxes. Nine was the greatest number found in this study in counts of embryos and fresh placental scars of 95 animals. There have been many reports of fox litters exceeding nine in number. D. F. Switzenberg of the Michigan Conservation Department (in litt. July 9, 1948) states that in 1946 three litters of ten were found, one of 15 and one of 14. He further reports that in the spring of 1948 a den dug out contained two adult females, one of which was nursing seven young just born, and the other contained five embryos; these observations suggest more than one litter in a den. Walter Stairs of Dryden, New York, recounted an instance of a den dug out several years ago in which were found one litter over four weeks old and a second litter of young with recently opened eyes. Such a difference in age is unusual. The occurrence of two litters in the same den of similar age might well confuse the uninitiated. In April 1948 William Mosensteen reported catching two nursing females and two adult males outside the same den in northern New York. In the spring of 1948 Thomas Dolan observed three adults outside a den eight miles south of Ithaca. Lundberg (1937) states that on occasion three adults of the European fox (*Vulpes vulpes*) may occupy a large permanent den.

On June 1, 1947, I trapped two vixens within 20 feet of each other on each side of a den entrance near Newfield, New York. Both vixens gave evidence of having nursed and weaned a litter, but one had obviously been dry some time longer than the other. Eight pups were caught at this den, four of which were at least two weeks or possibly three weeks younger than the other four. This gave definite proof of two litters living in the same den. On May

21, 1948, two vixens were caught four miles east of Ithaca, New York, in the same condition as those just reported. A total of nine pups was caught; these were judged to be of two litters with two weeks difference in age. Four of these were collected. The difference in size, particularly in the development of the brush, is apparent. The weights and measurements of these four pups are given in Table 1.

TABLE 1.—WEIGHTS AND MEASUREMENTS OF FOUR FOX PUPS COLLECTED FROM ONE DEN (5/21/48) BUT APPARENTLY REPRESENTING TWO LITTERS

	Large Litter		*Small Litter*	
	♂	♀	♂	♂
Weight	4⅛ lbs.	4¼ lbs.	3⅝ lbs.	3⅝ lbs.
Total length	890 mm.	709 mm.	660 mm.	691 mm.
Tail length	290 mm.	240 mm.	225 mm.	240 mm.
Length of hind foot	143 mm.	130 mm.	120 mm.	127 mm.
Height at shoulder	275 mm.	252 mm.	225 mm.	240 mm.
Ear length	75 mm.	75 mm.	68 mm.	65 mm.

While no more than nine pups were caught at either den, trapping experience indicates that more often than not a good share of the pups occupying a den escape.

Pups of two sizes were observed at a den near Townsend, New York, on May 5, 1948. This den had 27 holes and the forest floor was worn smooth by fox activity. From the amount of sign so early in the spring it is likely that at least two litters occupied the den site. Several experienced trappers said they had never seen another den of such size and with so much "sign."

No indication of male adults was apparent in the instances cited above. In the case of multiple denning, polygamy is suggested; definite evidence is lacking. The assumption that a vixen will move her litter to a fox den already occupied by another vixen and her young is indicated by field data.

On April 21, 1948, near Watkins Glen, New York, Leon Poelvoorde trapped one adult male red fox and one very small pup outside the entrance of an occupied den. The pup was judged to be four weeks old. The following day he caught an adult barren vixen within six feet of the den entrance and heard pups inside the den. On April 23 he caught one more pup and saw what was probably the adult vixen mother. On April 24 a third pup was caught outside the den, and a woodchuck was held alive in a trap directly in the den hole The vixen was seen and heard barking and whining within 30 yards. On April 25 two more pups were caught; no other foxes were subsequently taken.

High concentrations of fox litters often occur within a small area. The Newfield litters referred to above were living within 300 yards of a third litter and within less than half a mile of two additional litters. A state trapper took approximately 25 foxes within 100 acres on the area in the month of June. Four of these were adult females all of which had nursed pups. A fifth vixen, tagged and released earlier, was not recaptured. Two adult males were caught, and the remainder were pups.

In the same spring three separate litters were living near the Cornell University Poultry Farms within a quarter mile of one another. Two pairs of adults were observed accompanied by two litters at dens lying only 100 yards apart. A hole used by one family was

appropriated 48 hours later by another litter.

In 1948 four separate litters were found living within a half mile of one another. In June 1948 Cecil Barrett trapped pups of three litters 40 miles west of Ithaca; these were taken in three traps 200 yards apart.

Additional data were obtained through the tagging of pups. Near the poultry farm five pups of one litter were trapped and tagged on May 17, 1947. That same evening the vixen apparently moved this litter a half mile to a woodchuck hole just outside the poultry farm fence, for on May 19 one of the tagged males was caught in this hole. With him an untagged female pup was also trapped and killed. The female weighed a half pound more than the male, a condition which is significant. Male pups are invariably heavier than females of the same litter. Outside of this woodchuck hole an adult vixen was shot at the same time. It had six placental scars. Field observation of other litters suggests that this was a case of multiple denning. Three more of the tagged pups which had been caught May 17 were recaptured again at the original den in early June, and were being cared for by two adults. Presumably if they were in the woodchuck hole after the death of the vixen, only the male would remain to care for them. The fifth pup of this same litter was later dug out of another den a half mile from the original den and was apparently living with another litter, because the other pups removed from this den were untagged.

In May of 1948 three pups were captured and released outside a den eight miles north of Ithaca. At the time this den was occupied, another den in a wheat field a half mile away contained another litter. This second den was trapped a few days later and the three tagged pups recaptured with untagged pups of apparently another litter. Presumably the young had been moved to another den sharing it with a different family.

In certain instances of apparently mixed litters where the adults were not observed nor caught, there is the possibility that one vixen had moved her litter in different dens as much as a half mile apart. Scott (1943) cites an instance of one litter occupying one main den and using two other dens near-by as outlying retreats. On several occasions a den was found composed of holes separated by 100 yards or more, but well beaten trails connected them. It appears unlikely that the vixen would disperse her young in separate dens a half mile or more apart. However, Westell (1910) says it is not unusual for the vixen (*Vulpes vulpes*) to distribute pups when a month or six weeks old in two or three holes which may be as much as a mile apart.

There is evidence to suggest that an adult may foster a litter, as suggested above. In the spring of 1947 Walter Stairs dug out a litter of six fox pups about eight weeks old; they were placed in a shed separated by fur farm wire from an adult male fox which Stairs had dug out as a pup three years previously. This fox had not seen another fox since he was taken from the den. He was not very tame but was placid and shy when approached. As soon as the pups were placed next to him, he immediately adopted them and would bark excitedly, and aggressively try to bite through the wire when a visitor came in to look at them.

HOME RANGE

Seton (1929) describes the home range of a fox as "five miles across" except in unusual seasons of famine. Scott (1943) stated that observations of the northern plains red fox (*Vulpes regalis*) indicated that an arc drawn on a one-mile radius would ordinarily circumscribe the movements of the resident individual, pair or family. Murie (1944) showed by direct observations of particular individuals of the Alaskan red fox (*Vulpes kenaiensis*) that one male was observed at certain intervals near a cabin on Igloo Creek over a period of two years and three months, and another male occupied a range three miles across for the same period; one pair of unusually colored cross foxes used the same den for two years in succession and were seen in the vicinity during the winter.

The red fox is generally considered non-migratory with an attachment for a particular territory or home range. According to Seton (1929), the red fox makes no known migration. Scott (1943) records only local movements of a resident fox population such as concentrating activity around a muskrat marsh to take advantage of an easily available food supply in a drought year. Murie (1944) records an instance of the Alaska red fox moving into an area of high mouse population. He further recorded a scarcity of foxes in a region of mouse scarcity suggesting an alimental migration.

Many trappers and fox hunters have recorded information on the home range of the red fox. These people believe that the male fox often travels long distances at the height of the breeding season. Most of the evidence is based on tracking foxes in the snow or the extent of the area which a fox will travel when pursued by hounds. There is, however, little exact evidence on the actual range of any individual animal. Attention should be called to the experience of New York State trappers who have been taking foxes throughout the year during the recent rabies epizootic. These trappers unanimously agree that in the spring and summer they have "to go to the foxes" whereas in the fall and winter the foxes "come to them." This is a very general observation. It suggests that foxes have a greater range during the cold part of the year after families have dispersed than during the denning months. A trap set on a good fox "runway" often takes 25 to 30 animals during six weeks in the fall, whereas in the spring and and summer the same set may take only one or two individuals. The population is at a peak during the fall, but the difference in numbers would not be great enough to account for this discrepancy.

Another observation by experienced trappers in central New York is that during the fall invariably more males are trapped than females. Records of the New York State Conservation Department trappers in the vicnity of Seneca Lake are significant. Of 114 red foxes trapped between October 1 and December 31 (1947), 72 were males and 42 females. This predominant catch of males is not confined to New York State for Bennitt and Nagel (1937: 147) reported a sex ratio of Missouri red foxes based on trappers' returns of 60 males to 40 females.

There have been some remarkable records of distances travelled by individual foxes held captive and released

in a strange territory. Errington and Berry (1937) record one instance of an escaped captive travelling 160 miles. Such records quite obviously are not indicative of a fox's normal range in his familiar habitat. Errington likewise records returns of two fox pups released in the vicinity of their home den, one being trapped the following winter 16 miles away and the other 18 miles from the point of release in a different direction.

Of 38 fox pups tagged by the Cook method in the spring of 1947, there were 18 recaptures or returns before October 1. The evidence gathered from these returns supports in general the findings of Scott (1943) on the home range of fox families during the summer months. Scott observed that some fox families stayed together until September before eventual dispersal. Recaptures in this study showed that by the time pups are 12 weeks old, although still living in a den, they range quite widely during the night, a few having been recovered a half mile from their den. As nearly as could be determined, dens were deserted as permanent homes about the time lacteal dentition was being replaced. The latest date of an occupied den was recorded on July 10, 1947. After leaving the den, the pups usually ranged within a half mile of the old den, centering their activity around a patch of woods. This was evidenced not only by signs but by certain returns. A female pup banded May 18, 1947, was recaptured three months later within 50 feet of the old den site. This den had been abandoned in June. On September 15, 1947, a juvenile male was recaptured within a quarter mile of the den site where he had been banded on May 27. A male pup banded May 30 was shot within 100 yards of the original den site on August 10.

Of particular interest are some October returns of banded pups. Three young of one litter were recaptured or killed between October 20 and 23. Two of these were vixens which were caught on successive days at the same set approximately three quarters of a mile from their old den site. No appreciable dispersal had taken place. On October 20 a male from the same litter was taken five and a half miles from the den. This suggests he was seeking a new territory. On October 10 a vixen pup was killed a quarter of a mile from her natal den. A female pup was shot October 20 one and one quarter miles from the point of release. Table 2 indicates the tendency of the males to wander is as characteristic of foxes as of many other animals. This table does not include returns recounted above.

Fifty-nine red foxes were tagged between September 15 and October 30, 1947. Returns on 18 of these foxes are available to July 1948. The age of some animals taken in October may be problematical. Adults could be recognized in some instances by the tooth wear.

One adult male travelled at least 40 miles from the point of initial capture in eight weeks. Another adult moved 23 miles in 11 days during late October. The chances are likely that no. 117 died of rabies, but the animal could not be procured for a diagnosis. Males of all ages show a marked tendency to travel in mid-fall. The longest distance recorded for a female was two miles; this animal was shot ahead of hounds and was reported to have been started

seven miles from the original point of capture. One old vixen, no. 121, was found dead. D. F. Switzenberg (in litt. July 9, 1948) of the Michigan Conservation Department stated a juvenile male fox tagged at a den on May 22, 1945, was trapped the following October, 30 miles distant. He further stated that one female pup travelled 20 miles between May and November 1944, and another female pup was shot in late November 1944, 27 miles from the den where she was released in May. These records indicate that female pups, as would be expected, disperse as well as males.

Therefore, field observations of marked foxes clarify the findings of trappers. In the spring there are local movements to denning areas. This accounts for the seasonal concentration of foxes. The young remain in the general vicinity of the den until October when they begin to disperse. Both male pups and adults travel widely in the fall. This presumably accounts for the preponderance of males caught by trappers at this season. It is possible that with the initiation of the estrus cycle females may wander widely if unmated. In the Catskills of New York where water sets are most effective during deep snows, the sex ratio of foxes caught in January and February is reportedly about even. The evidence indicates that food supply would not influence the movements of foxes, particularly in the fall months.

TABLE 2.—MOVEMENTS OF RED FOXES TAGGED BETWEEN SEPTEMBER 15–OCTOBER 30, 1947

No.	Sex	Age	Date Tagged	Date Recovered	Distance (in Miles)	Cause of Death
147	♂	pup	Sept. 15, '47	Mar. 6, '48	16	Rabies—(shot)
145	♂	mature	Sept. 17, '47	Dec. 3, '47	11	Trapped
150	♂	mature	Sept. 25, '47	Dec. 1, '47	40	Trapped
136	♂	pup	Sept. 29, '47	Nov. 13, '47	7¾	Shot
132	♂	mature	Oct. 15, '47	Oct. 21, '47	1	Shot
117	♀	mature	Oct. 19, '47	Apr. 12, '48	3	Undetermined
88	♂	mature	Oct. 20, '47	Nov. 2, '47	23	Trapped
99	♂	pup	Oct. 20, '47	Nov. 12, '47	10½	Shot
75	♂	pup	Oct. 21, '47	Nov. 12, '47	10½	Shot
125	♂	mature	Oct. 23, '47	Feb. 10, '48	3¾	Rabies—(shot)
72	♂	pup	Oct. 25, '47	Nov. 23, '47	11¾	Trapped
87	♂	mature	Oct. 25, '47	Dec. 13, '47	16¾	Trapped
89	?	pup	Oct. 30, '47	Nov. 24, '47	4¾	Undetermined
156	♀	pup	Sept. 30, '47	Oct. 10, '47	½	Trapped
133	♀	pup	Oct. 6, '47	Nov. 24, '47	1/10	Shot
94	♀	mature	Oct. 9, '47	Jan. 11, '48	1	Shot
121	♀	mature	Oct. 23, '47	June 6, '48	½	Undetermined
82	♀	mature	Oct. 25, '47	Jan. 10, '48	2	Shot

The data suggest that the female establishes the home range for a fox family and that she usually locates and digs out the old dens.

SUMMARY

1. Most of the data presented are based on field observation and the tagging and releasing of 120 red foxes.

2. Of 50 den sites examined, all except four were found in sandy soil.

3. Some dens provided only tempo-

rary retreats; the largest and most permanent rearing dens were found in woods.

4. Foxes were observed to be gregarious during the denning season.

5. A high degree of intraspecific tolerance was suggested by fox behaviour.

6. Instances of two litters occupying the same den were not uncommon.

7. Communal behaviour was further suggested by instances of vixens moving litters into dens already occupied by separate litters.

8. Large concentrations of litters were found, such as five litters within 200 acres.

9. Pups of one litter occasionally became mixed up with other families.

10. The experience of state trappers working during the denning season indicates the range of the adult animals is limited at this time of year.

11. Approximately 40 returns on banded red foxes provided data on home range and movements.

12. The evidence suggested that dens are abandoned about the time the pups lose their lacteal dentition. Fox families remain more or less united living within a mile or less of the natal den until late September or October.

13. The male pups are the first to disperse. Several returns indicated dispersals over 15 miles.

14. Returns on adults indicate that the male red fox wanders widely in the fall months. One adult moved 23 miles in 11 days. Another banded in late September was recovered 40 miles away in early December.

15. The longest return on a female was two miles although there is other evidence that female pups disperse widely.

16. These data suggest the vixen establishes the home range of a fox family and that males are "residents" of an area for a relatively short period of the year.

17. These findings clarify the experience of trappers working during twelve months of the year. In the spring and summer there are local movements to denning areas where often there may be a heavy concentration of animals with a limited range. In the fall the population is more mobile but more evenly distributed.

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VITAMIN A IN PHEASANTS, QUAIL, AND MUSKRATS[1]

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INTRODUCTION

That vitamin A might be a vital factor in determining population levels of bobwhites and other gallinaceous birds in the wild was suggested by Nestler (1946) who observed symptoms of vitamin A deficiency in bobwhite quail (*Colinus virginianus*) fed insufficient amounts of the vitamin. He also determined the levels of vitamin A required in the diet of captive quail for breeding, growth, and maintenance. Wisconsin includes the northern boundary of two of our most important gallinaceous game birds, the ringnecked pheasant (*Phasianus colchicus*) and the bobwhite quail, and hence this region appeared suitable for testing whether the amounts of vitamin A in wild birds might be important in affecting population levels. In the present study a survey was made of the amounts of vitamin A encountered in these and other species at various times of the year, with emphasis on the question of whether or not a seasonal deficiency of vitamin A occurs in these species in the wild.

MATERIAL AND METHODS

The livers of 154 wild pheasants were analyzed for vitamin A by the $SbCl_3$ method (Carr and Price, 1926). Sixty-one of these birds were shot on the University Bay area near Madison during 1946 and 1947. This is an area of 400 acres consisting of mixed cropland, meadow and upland hardwood on Miami silt loam. It is operated as part of the University of Wisconsin farms and includes a large acreage of corn and pasture. Most of the remaining wild pheasants were obtained within 25 miles of Madison, largely from the University

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of Wisconsin Arboretum and the marshes adjoining the Nevin State Fish Hatchery. A few were taken in Dunn County in the west-central part of the state, and eighteen were obtained from South Dakota. Thirty-eight specimens of bobwhite quail were taken for analysis from the southwestern part of the state, largely along the Wisconsin River north of Mazomanie.

At autopsy, data were recorded on sex, age, weight, organ and gland weights and/or measurements, ovulated folliciles (pheasants only), and crop contents. Gross inspection was also made for pathological symptoms. The ages of juvenile pheasants up to 16 weeks of age were determined by examination for the stage of the primary molt. Ages over 16 and up to 30 weeks were determined only approximately by calculation from the peak of hatching in the 1946 breeding season (Thompson and Taber, 1948). Ages of immature juvenile bobwhite quail were estimated by the method of Petrides and Nestler (1943). Mature juveniles were distingushed from adults by the coloration of the greater upper primary coverts (Leopold, 1939). The livers were removed from the specimens, placed in closed 2- or 4-ounce jars and kept in the frozen state (15°F.) until assayed for vitamin A. Samples of kidney tissue were taken from some of the specimens, and these were handled in the same manner as the livers. Apparrently there was no loss of vitamin A in the liver when kept in a frozen condition for periods up to four weeks (Thompson, 1948).

Preparatory to assay, entire livers or aliquots of livers weighing 4 to 8 grams were digested in 8 per cent KOH and the vitamin A and carotenoid pigments extracted as described by Johnson and Baumann (1947a). The Carr-Price reaction was employed in treating the extracts, and the intensity of the blue color resulting was measured in an Evelyn photoelectric colorimeter (Dann and Evelyn, 1938). Since the extracts were yellow in color, the intensity of the color was measured and calculated as "carotene" (Johnson and Baumann, 1947b), although extraction of the crude ether extracts with 90 per cent methyl alcohol indicated that 45 to 65 per cent of the yellow color was due to xanthophyll.

The quantities of carotenoid thus determined ranged from 1 to 10 per cent of the amounts of vitamin A present. Since the chromogenic potency of the carotenoids with $SbCl_3$ is much less than that of vitamin A, it appeared that the amounts of carotenoid pigment present did not seriously interfere with the determination of vitamin A. This was confirmed by R. M. Johnson of the Department of Biochemistry in the following way. The unsaponifiable matter from aliquots of pheasant livers was dissolved in petroleum ether (Skelly Solve B) and poured through a column of three parts of $Ca(OH)_2$ and one of Hi-Flo super-cell and developed with a 3 per cent solution of Skelly Solve B. A small, fast-moving yellow band was washed completely through the column at which time two other yellow bands had separated at the top and one-third of the way down the column. A wide band of vitamin A in the lower half of the column was revealed by stippling the sides with $SbCl_3$ reagent. The values for the vitamin A fraction of four livers analyzed two at a time are given in Table 1.

The maximum discrepancies between

the analyses of the crude and purified extracts were therefore only 8 and 9 per cent, which was considered to be satisfactory for the purposes of this survey. In view of the fact that some loss of vitamin A is possible on the chromatographic column, it appeared that the blue color with $SbCl_3$ on which the determinations of vitamin A were based was indeed due primarily to the vitamin itself.

TABLE 1.—EFFECT OF CHROMATOGRAPHY ON THE ANALYSES OF PHEASANT LIVERS FOR VITAMIN A
(Data of R. M. Johnson)

Basis of Determination	Micrograms Vitamin A per gm. of Liver	
	Livers 1 and 2	Livers 3 and 4
Purified eluate	376	323
Crude extract but corrected for chromogenic power of the combined carotenoid fraction	400	339
Uncorrected crude extract	413	350

Inasmuch as the kidneys of rats have been found to accumulate vitamin A preferentially over the liver when the total amount in the body is low (Johnson and Baumann, 1947a), the kidneys of 5 wild pheasants were assayed for the vitamin. The total quantities found ranged from 0.25 to 0.32 mg. per pheasant, and these amounts represented only 2 to 3 per cent of the quantities found in the livers of the same birds. Thus the kidney of the pheasant did not appear to be an important storage organ for vitamin A, and in this respect the pheasant resembles the domestic growing chick (Johnson, 1948) more closely than the laboratory rat.

RESULTS

Wild Wisconsin Pheasants. Table II lists the quantity of vitamin A found in the livers of wild juvenile Wisconsin pheasants in 1946–47 according to the ages of the juveniles. The data indicate the rapid gains in vitamin A storage made by pheasants early in life. Not only was there an increase in the total amount of vitamin A in the liver, but the concentration of vitamin A per gram of liver increased while the liver itself was increasing in size. At the age of 12 to 15 weeks, the total stores approached the quantities found in pheasants over 30 weeks in age (Figure 1). The quantity stored is about ten times the daily requirement of vitamin A recommended by the National Research Council for human beings.

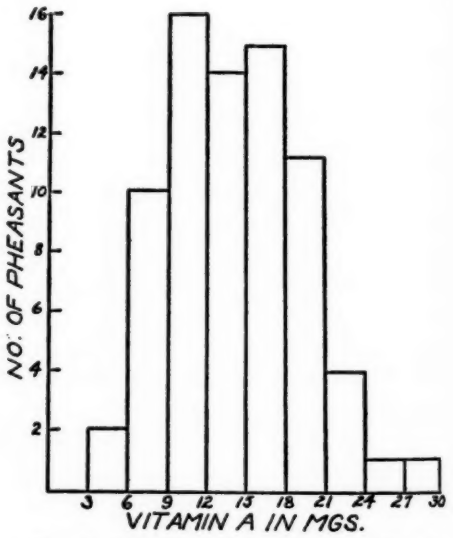

FIG. 1. Quantity of vitamin A per liver in 74 wild Wisconsin pheasants over 30 weeks in age, 1946–47.

Figure 1 shows the total quantity of vitamin A found in the livers of 74 Wisconsin pheasants over 30 weeks of age.

Twenty-nine of these pheasants were between 30 and 52 weeks of age, 30 were over 52 weeks of age, while the ages of the remaining 15 were uncertain but known to be over 30 weeks of age. These ages are of interest from the wildlife management standpoint because they embrace the ages of most pheasants during the critical winter period.

TABLE 2.—VITAMIN A STORED IN LIVERS OF WILD JUVENILE WISCONSIN PHEASANTS, 1946–1947

Age	No. of Specimens Examined	Mean mg./g. of Liver	Mean Total per Liver in mg.	Range of Totals per Liver in mg.
20- to 24-day embryo	10	—	0.007	—
Hatch to 5 weeks	3	0.083	0.44	0.175– 0.67
6 to 10 weeks	12	0.210	3.10	0.95 – 7.40
11 to 15 weeks	12	0.490	9.45	5.80 –15.30
16 to 20 weeks	8	0.530	10.80	3.70 –13.70
21 to 30 weeks	6	0.515	9.15	5.95 –12.20

However, only 50 of the pheasants were obtained between January and June with the remaining 24 being taken at other seasons of the year.

The mean quantity of vitamin A stored by 84 pheasants over 30 weeks of age was 13.3 mg., and the mean quantity found per gram of liver was 0.705 mg. These means include the 74 birds given in Figure 1 and in addition 10 birds that were excluded from Figure 1 because they involved lumped analyses. Thus the older pheasants appear to contain about 30 per cent more vitamin A than the birds of 12 to 15 weeks of age (Table 2).

The total quantity of vitamin A stored by males appeared to be significantly higher than that found in females. For pheasants over 30 weeks of age the average stored by 45 females was 12.7 mg. and for 32 males was 15.3 mg. This difference may be due to the difference in liver weight between the two sexes, since the average quantity of vitamin A stored per gram of liver is practically the same for the two sexes: 0.73 mg. per gram of liver for males, 0.70 mg. for females.

No seasonal difference was apparent in the quantity of vitamin A stored in pheasants, though close comparison was impossible due to the limited scope of the collection and the large variation between individuals. Table 3 compares the mean values found in summer- and winter-collected specimens.

The amounts of vitamin A in males were slightly lower in winter in than summer while in females they were somewhat higher in winter than in the summer but these differences were not statistically significant.

South Dakota Pheasants. In addition to the Wisconsin pheasant material,

TABLE 3.—SEASONAL LEVEL OF VITAMIN A STORAGE IN PHEASANTS, 1946–47

Collection Period	Males		Females	
	No. of Spec.	Mean Vit. A in mg.	No. of Spec.	Mean Vit. A in mg.
7/ 9–8/29	6	17.2	12	10.8
1/12–3/13	12	15.8	13	13.8

assays were made on 18 wild pheasants from South Dakota taken in October in 1946. Eight hens contained an average of 10.0 mg. of vitamin A per liver, while the ten cocks averaged 10.6 mg. Since most of these were fall juveniles, it is apparent that the amounts of vitamin A found correspond closely to those in Wisconsin juvenile pheasants (Table 2).

TABLE 4.—VITAMIN A STORAGE IN LIVERS OF WISCONSIN BOBWHITE QUAIL, 1946–47

Age	No. of Specimens	Average Total Vitamin A in mg.	Range of Total Vitamin A
65– 84 days	6	0.55	0.22–0.73
85–104 days	4	0.72	Lumped
105–124 days	4	0.90	0.81–0.95
125–144 days	7	0.86	0.56–1.15
Juv. over 144 days	7	1.02	0.44–1.65
Adults	10	0.99	0.36–1.95

Game Farm Pheasant Releases. Pheasants to be released by the "gentle" method (Kozlik, 1948) were obtained through the cooperation of the Wisconsin Conservation Department from the Elk Mound Public Hunting Ground. Two chicks taken at the age of eight weeks, at which time the birds were placed in the confinement of the release pen, contained only 36 and 40 μg. of vitamin A per gram of liver as contrasted with 170 μg. in wild birds of approximately similar age. At ten weeks of age when the release pen was opened, three more of the chicks were taken for assay. These averaged 50 μg. of vitamin A per gram of liver. During the following hunting season livers were obtained for assay from four of the release birds shot on the area. The assays, revealed that storage had increased to an average of 240 μg. of vitamin A per gram of liver, indicating that very appreciable gains in vitamin A storage had been made by these birds when "on their own." Wild juvenile birds taken at the same time on the same area averaged 490 μg. per gram of liver.

In addition to these, four "gentle release" pheasants were recovered from the Mazomanie Public Hunting Ground. These four averaged 200 μg. storage per gram of liver with an average total of 4.8 mg. of vitamin A.

Experimental studies on the effect of egg-laying on the quantity of vitamin A in storage in breeder hens were made in connection with endocrine studies by Frederick Greeley (University of Wisconsin) at the Wisconsin State Experimental Game and Fur Farm (Thompson, 1948). Birds were fed the standard laying mash given to all breeding hens at the farm. Three groups, each containing 20 to 25 hens, were examined. The first group was autopsied at the time of laying of the first egg, the second after laying 30 to 40 eggs, and the third group at the time of complete cessation of laying. Total storages of vitamin A for the three groups respectively were 3.4 mg., 2.8 mg., and 2.95 mg. These results indicate that heavy egg-production did not tax the vitamin A reserves of the hens.

Bobwhite Quail. The quantities of vitamin A found in livers of quail of various ages above 65 days are presented in Table 4.

All samples analyzed contained vitamin A, the amounts ranging from 0.22 to 1.95 mg. As in pheasants the amount of the vitamin in young quail increased with age up to a certain point; after 124 days there was no further consistent increase with age. Only three of the birds analyzed were obtained during

January and February, but these three birds contained an average of 1.11 mg. of vitamin A per bird, i.e., at least as much as in birds obtained during other seasons of the year. There was, therefore, no evidence of vitamin A deficiency during the winter months, although admittedly the number of analyses was too small for any significance to be attached to the results.

Nestler (1946) examined 45 wild quail collected in the winter and found the average vitamin A content to be 840 I.U., which is equivalent to 0.19 mg. He states that "at least 31 per cent, or nearly one-third, had not enough vitamin A stored in their livers to help them survive more than four weeks of a deficiency of this factor in their diet." This survival expectation was based on work with captive quail and on the assumption that no further vitamin A would be available to the wild birds during this time. The average quantity stored by quail reported in the present study is approximately five times as great as that reported by Nestler. Despite a number of much-appreciated conferences with Mr. Nestler, we are unable at this time to offer an explanation for the discrepancy between our results and his.

The storage levels encountered in this survey suggest that the spontaneous development of a deficiency of vitamin A in the 1946–47 Wisconsin quail would have been only remotely possible, and even less likely in view of the fact that even the poorest winter diet contains some provitamin A.

An interspecific difference between quail and pheasants is indicated by the fact that during the same year pheasants stored ten times as much vitamin A as quail, although the weight of the pheasant is only about six times that of the quail. The proportion of yellow pigments to vitamin A in the liver appeared to be essentially the same in the quail as in the pheasant.

Other Species. A clutch of wild mallard (*Anas platyrhynchos*) eggs was collected at the Nevin State Fish Hatchery marsh area just as the young were pipping the shells. The average liver weight of the hatching ducks was 0.728 grams. Vitamin A in the livers ranged from 11 to 43 μg. These levels were somewhat higher than those found in pheasant chicks which were about to hatch (Table 1).

Livers of muskrats (*Ondatra zibethica*) from the Horicon Marsh Wildlife area were provided in September, October, and November of 1946, and February of 1947 by James Beer (University of Wisconsin), and these were assayed for vitamin A by the same method used for the avian livers. The unsaponifiable matter from the muskrat livers contained much less pigment than that from pheasants or quail, and in this respect the muskrat appears to resemble the common laboratory rat. All samples

TABLE 5.—LEVELS OF VITAMIN A IN MUSKRATS, 1946–47

Month of Collection	Age	No. of Specimens	Average Total Vitamin A in mg.
September, 1946	Juveniles	12	1.07
	Adults	2	1.96
October, 1946	Juveniles	8	2.09
	Adults	4	4.80
November, 1946	Juveniles	6	2.27
	Adults	3	6.87
February, 1947	Juveniles	4	1.65
	Adults	4	1.54

of muskrat liver contained appreciable quantities of vitamin A, the average for 43 specimens being 2.32 mg. per rat. The amounts in adult rats were usually higher than those in juveniles (Table 5). The average amount of vitamin A, however, was only about one-fifth that found in pheasants, although the body-weights are similar for the two species. The difference in level of storage presumably reflects differences in food habits, efficiency of conversion of precursors of vitamin A into the vitamin, efficiency of absorption, and possibly in the amounts of the vitamin used daily.

DISCUSSION

The high levels of storage of vitamin A found in all the wild specimens analyzed suggests that the intake of active carotenoids and their conversion to vitamin A took place to a degree far in excess of the daily needs of the animal. Storage usually represents a surplus inasmuch as in some species, at least, the animal may remain in good health without the accumulation of stored vitamin A. In the laboratory rat the dose required for storage to take place is considerably greater than the dose required for growth and freedom from deficiency symptoms.

No cases of vitamin A deficiency were noted in the 154 wild pheasants examined nor in the game farm pheasants. The mean values of total vitamin A found in wild pheasants would meet the optimum vitamin A requirement of an adult human being for a period of about two weeks. The pheasant's weight is only about 2 per cent that of man, and while the pheasant may require proportionately more vitamin A because of a higher metabolic rate, it nevertheless appears unlikely that vitamin A deficiency was a factor in the survival of the populations from which these birds were taken.

Studies made in other years and on other areas might yield significantly different levels of storage of vitamin A. Assuming a normal diet, the carotene content of the ingested food would be the main cause for such differences. The carotene content of plant materials may be influenced by factors that unfavorably affect the growth of the plant. Carotene content of herbage decreases markedly in dry weather when plants lose their green color.

It is to be assumed, however, that a vitamin A deficiency superimposed on other factors unfavorable for survival would contribute to mortality in gallinaceous populations. It might be questioned to what extent a survey such as the present one can be expected to reveal the extent or importance of vitamin deficiency in any wild species, since any severely deficient birds, if such had existed, would presumably have been wiped out prior to sampling. However, the absence from the survey material of any specimens containing only traces of vitamin A would seem to imply that those birds analyzed, at least, were not obviously heading for vitamin A deficiency.

SUMMARY

Measurements were made of the vitamin A stored in the livers of pheasants, quail and muskrats to determine the amounts normally present and to determine whether prominent seasonal deficiencies develop.

(1) The quantity of vitamin A found in pheasants increased from less than 10 μg. at hatching to 10 mg. at about

15 weeks of age. In 84 birds over 30 weeks old it averaged 13.3 mg. (2) The amounts in pheasants collected in winter equalled those in birds collected in summer. (3) Male pheasants contained roughly 20 percent more vitamin A than females, unit storage being almost equal in the two sexes. (4) South Dakota pheasants contained approximately the same amounts of vitamin A as Wisconsin birds of similar age. (5) Released juvenile game farm pheasants, recovered during the hunting season, contained 50–60 per cent less vitamin A than wild juvenile birds at that time, yet they had made very substantial gains in storage during their period in the wild. (6) Heavy egg-production did not seriously tax the vitamin A reserves of a group of game farm breeder hens.

(7) Among 38 bobwhite quail no deficiency of vitamin A was found, the storage increasing with age as in pheasants. On a body-weight basis quail averaged only one-half as much vitamin A as pheasants.

(8) Livers of wild mallard ducks at hatching contained from 11 to 43 μg. of vitamin A.

(9) 43 muskrats collected during fall and winter averaged 2.32 mg. of vitamin A with the adults usually having a greater quantity.

(10) Inasmuch as no cases of zero or of very low storage of vitamin A were encountered in the species studied, it seems unlikely that the populations sampled could have suffered seriously from vitamin A deficiency.

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FOOD, GROWTH AND HABITS OF FINGERLING NORTHERN SMALLMOUTH BASS, *MICROPTERUS DOLOMIEU DOLOMIEU* LACÉPÈDE, IN TROUT WATERS OF WESTERN NEW YORK

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The predatory food habits of the smallmouth bass, *Micropterus dolomieu*, have long been known. The presence of the smallmouth in trout streams has caused some sportsmen in northeastern United States to condemn it in favor of a more desired species of trout. Undoubtedly, competition arises where these species are found together. However, the extent of this competition requires considerable additional study before any but tentative conclusions can be drawn. The smallmouth bass is commonly found with brown trout, *Salmo trutta fario*, in certain central Pennsylvania waters.

The New York Conservation Department continued its ecological and population studies of trout streams in the West-Central Fish Management District in 1941. Fish populations were determined by the use of the electric shocker in several sample stream sections. Young (fingerling) smallmouth bass from two of these sections were made available to the writer for study.

The material was taken from two 100-yard sections of the East Koy Creek, a tributary of the Genesee River, in an area from 1 to 1½ miles above Gainesville, Wyoming County, New York. Here the stream has a fairly low gradient, with some riffles, several good pools, and an average width of about 35 feet. The bottom is chiefly of rubble, gravel, and sand composition. A total of 248 fingerling smallmouth bass was taken from these 200 yards of stream sections on August 11 and 12, 1941.

Method of Analysis

For each specimen, the standard length was measured, and stomach contents were studied. Organisms present were sorted in a watch glass, identified, counted, and the volume of each carefully estimated. All of the bass were in their first summer. They varied considerably in length and it became evident upon the examination of a few stomachs that the larger bass were eating fishes and crayfishes almost exclusively, while the smaller specimens subsisted chiefly on insects. If 5 insects constituted the stomach contents of a single bass, these were recorded as 100 per cent by volume, although they may have been only one tenth the volume of a single darter in another stomach. It was realized that adjustments in volume due to the size and type of organism present would lead to inaccurate figures especially when considering the small food items of the smaller bass. To allow for this, the data were tabulated for bass in length groups of 10 mm.

The standard lengths of fishes eaten were also measured when possible. Forage fishes such as the barred fantail darter, *Poecilichthys f. flabellaris*, were frequently aged by scale examination.

Growth

The mean standard length of 248 smallmouth bass taken August 11 and

12, 1941 was 52.0 mm. The great variability in size is shown in Table 1 by the platykurtic nature of the length-frequency distribution. The large standard deviation (12.12) of this distribution is further evidence of this variability. Perhaps this platykurtic distribution is associated with the transition in diet, for bass about 40 mm. began eating fish and crayfish along with their insect diet, (Fig. 1), and these food organisms which provide far greater bulk may produce relatively greater growth increments. A more normal length-frequency distribution may occur when all bass are of sufficient size to master fishes and crayfishes as food organisms.

TABLE 1.—LENGTH-FREQUENCY DISTRIBUTION OF 248 FINGERLING SMALLMOUTH BASS, *Micropterus d. dolomieu*, TAKEN AUGUST 11 AND 12, 1941 FROM THE EAST KOY CREEK, ABOUT 1 TO 1½ MILES ABOVE GAINESVILLE, WYOMING COUNTY, NEW YORK

Standard length in mm.	32–35	36–39	40–43	44–47	48–51	52–55	56–59	60–63	64–67	68–71	72–75	76–79
Number	21	26	15	23	23	20	25	30	33	19	11	2

FOOD

Nine orders of insects; five species of minnows, Cyprinidae; one species of darter, Percidae; a terrestrial arachnid; and copepods, ostracods and crayfishes (*Cambarus*), were identified in stomachs of the bass. These data are summarized in Table 2. There were no appreciable differences in these data when compared to other studies made on young bass, such as those of Wickliff (1920), Tester (1932), and Surber (1941).

Nearly all the insect food was aquatic. Ephemeroptera (non-burrowing forms, Heptageniidae and Baetidae), Hemiptera (Corixidae and Notonectidae), and Diptera larvae (chiefly *Chironomus*) were most commonly taken and formed the greater percentage of volume of insect food. Other insect organisms identified were the alderfly, Sialidae (Neuroptera), the water-penny, *Psephenus* (Coleoptera), ants, Formicidae (Hymenoptera), and several species of pupating and adult flies (Diptera). Among the crustacean food, copepods (*Cyclops*) and crayfishes (*Cambarus*) were frequently ingested. *Cambarus* was found in 23.4 per cent of all stomachs containing food but appeared in only 1 stomach of a bass under 50 mm. The copepods were found in 18.4 per cent of the stomachs and occurred chiefly in stomachs of bass under 50 mm. in standard length. Ostracods were found in only 2 stomachs. Several large water spiders (Arachnida) were eaten.

Of the six species of fishes found in the stomach contents, the barred fantail, was the most important forage species and appeared in 15.8 per cent of all stomachs examined. Sometimes two darters were found in a single stomach. Their heads and bodies were usually coiled and partly digested in the stomach while the caudal fin remained in the gullet or mouth cavity. Some darters were quite large. One 68 mm. bass had eaten a 46 mm. darter. Most of the darters were young of the year, but scale examination indicated that sev-

TABLE 2.—FOOD OF 222 FINGERLING SMALLMOUTH BASS, *Micropterus d. dolomieu*, TAKEN AUGUST 11 AND 12, 1941 FROM THE EAST KOY CREEK, ABOUT 1 TO 1½ MILES ABOVE GAINESVILLE, WYOMING COUNTY, NEW YORK. THE MEAN STANDARD LENGTH WAS 52.0 mm. AND THE SIZE RANGE EXTENDED FROM 32 TO 78 mm. THE TOTAL NUMBER OF STOMACHS EXAMINED WAS 248; 26 WITH NO FOOD

	Number of Stomachs Containing Item	Average Number of the Item per Stomach When Present	Percentage of Stomachs Containing Item	Percentage of the Volume of All Food
Insects				
Stone flies, Plecoptera	1	1.0	0.5	+
Mayflies, Ephemeroptera	91	3.2	40.5	23.7
Caddisflies, Trichoptera	6	1.3	2.7	0.7
Alderflies, Neuroptera	1	1.0	0.5	+
Water bugs, Hemiptera	33	2.3	14.9	6.3
Midges, etc., Diptera				
adult	2	1.0	0.9	0.6
pupae	8	1.5	3.6	1.2
larvae	5	1.6	2.2	0.4
Chironomus	26	2.3	11.7	1.8
Water beetles, Coleoptera	1	1.0	0.5	0.3
Ants, Hymenoptera	2	1.0	0.9	0.1
Moths, Lepidoptera	1	1.0	0.5	+
Insect Remains	14	1.1	6.3	2.3
Spiders, Arachnida	2	.0*	0.9	0.6
Crustaceans				
Crayfish, *Cambarus*	52	1.0	23.4	19.6
Copepods	41	34.1	18.4	11.7
Ostracods	2	1.5	0.9	+
Fishes				
Minnows, Cyprinidae				
Central stoneroller, *Campostoma anomalum pullum*	1	1.0	0.5	0.5
Bluntnose minnow, *Hyborhynchus notatus*	7	1.1	3.2	1.8
Northern common shiner, *Notropis cornutus frontalis*	2	1.5	0.9	0.5
Western blacknose dace, *Rhinichthys atratulus meleagris*	4	1	1.8	1.6
Northern creek chub, *Semotilus a. atromaculatus*	1	2	0.5	0.5
Cyprinidae Remains	18	1	8.1	7.9
Perches, Percidae				
Barred fantail, *Poecilichthys f. flabellaris*	35	1.2	15.8	13.5
Fish Remains	14	—	6.3	4.5

+ = Less than 0.1 per cent.

eral larger specimens were in their second year.

No bass under 40 mm. had eaten any fish. It is of interest that the fantail darter appeared in about as many stomachs as all 5 species of cyprinids. Of the minnows, the bluntnose, *Hyborhynchus notatus*, was most commonly taken. The transition in diet from insect to fish and crayfish food is shown diagrammatically in Figure 1.

SELECTIVITY

Many investigators have noted the improper conclusions that are frequently formed regarding food analyses by referring to certain foods most frequently taken as preferred items. These conclusions are frequently invalid unless quantitative data of the abundance of the food organisms are at hand. Even if such data were present, the variability of many quantitative data may be so great as to be unreliable, and the determination of food predilection by a given species may be extremely difficult. Food organisms present in greatest abundance, are eaten most frequently when there is no selectivity in the feeding habits (Hubbs and Bailey, 1938).

The fish populations in the two 100-yard stream sections from which the 248 fingerling bass in this study were taken, were determined by the electric shocker. These data were made available by the New York Conservation Department (Anonymous, 1941). A comparison of the forage fish population of these two sections with the fish taken as food by fingerling bass from the same sections is presented in Table 3 by frequency and in per cent of total catch. However, direct comparisons are not justified between numbers of fishes eaten with numbers taken from each section. In sampling with the electric shocker many young fishes probably were not taken, for they pass through the dip nets, are difficult to remove from water, and are easily overlooked in roiled water. Most of the fish food of the young bass was young and small juvenile fishes.

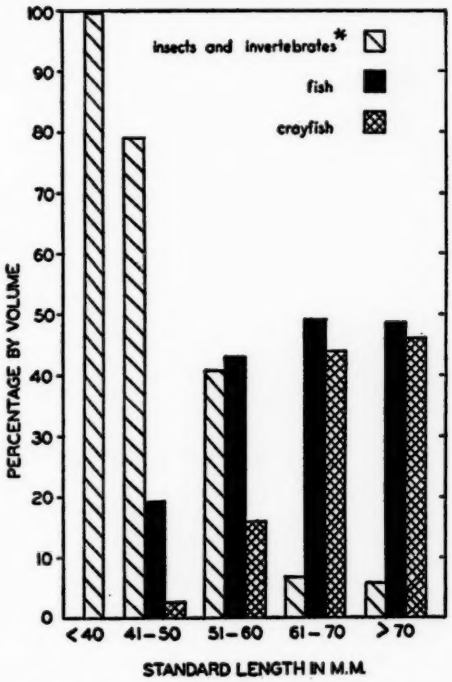

FIG. 1. Diet transition with increase in size of 222 fingerling smallmouth bass, *Micropterus d. dolomieu*, taken August 11 and 12, 1941 from the East Koy Creek, a tributary of Genesee River, Wyoming County, New York. (*Other than crayfish.)

The four forage species that were most common in the stream were not frequently eaten. These were the northern common shiner (*Notropis cornutus frontalis*), the bluntnose minnow (*Hyborhynchus notatus*), the central stoneroller (*Campostoma anomalum pullum*),

TABLE 3.—COMPARISON OF FISH FOOD OF THE SMALLMOUTH BASS, *Micropterus d. dolomieu*, FROM THE EAST KOY CREEK, WITH THE FISH POPULATIONS. THE FISH POPULATIONS OF THE CREEK WERE DETERMINED BY THE USE OF THE ELECTRIC SHOCKER IN TWO 100-YARD SECTIONS. A TOTAL OF 248 FINGERLING BASS WAS TAKEN FROM THESE SECTIONS

	August 11, 1941 100-Yard Section. 132 Bass Examined 12 Empty				August 12, 1941 100-Yard Section. 116 Bass Examined 14 Empty			
	Number of Fishes		Per Cent of Total		Number of Fishes		Per Cent of Total	
	Str.	*Sto.*	*Str.*	*Sto.*	*Str.*	*Sto.*	*Str.*	*Sto.**
Suckers, Catostomidae								
Common white sucker, *Catostomus c. commersonii*	85	—	6.4	—	74	—	10.6	—
Minnows, Cyprinidae								
Central stoneroller, *Campostoma anomalum pullum*	274	—	20.6	—	60	1	8.6	2.2
Bluntnose minnow, *Hyborhynchus notatus*	319	6	23.9	13.7	93	—	13.2	—
Allegheny pearl dace, *Margariscus m. magarita*	29	—	2.2	—	7	—	1.0	—
Northern common shiner, *Notropis cornutus frontalis*	512	2	38.4	4.6	221	1	31.8	2.2
Western blacknose dace *Rhinichthys atratulus meleagris*	10	—	0.8	—	83	4	11.9	8.9
Northern creek chub *Semotilus a. atromaculatus*	83	2	6.2	4.6	135	—	19.3	—
Cyprinidae Remains	—	9	—	20.4	—	9	—	20.0
Perches, Percidae								
Barred fantail darter *Poecilichthys f. flabellaris*	3	23	0.2	52.3	20	18	2.9	40.0
Sunfishes, Centrarchidae								
Northern rock bass, *Ambloplites r. rupestris*	6	—	0.5	—	6	—	0.9	—
Pumpkinseed, *Lepomis gibbosus*	14	—	1.1	—	1	—	+	—
Fish Remains	—	2	—	4.6	—	12	—	26.7

+ = Less than 0.1 per cent.
* Str. = stream; Sto. = stomach.

and the northern creek chub (*Semotilus a. atromaculatus*). While only 3 barred fantail darters were taken in one 100-yard section by electric shocker and 20 in the second section, a total of 41 fantail darters were found in the stomachs of bass from both sections and represented 52.3 per cent and 40 per cent of the fish food from these sections (Table 3). Although efficiency tests to check the recovery of marked trout (7 inches or larger) in shocker operations in these sections averaged about 90 per cent, undoubtedly many fantails were missed. These small percid fishes lack air bladders, are frequently shocked when under stones and may never float and become visible to the collector. Nevertheless, from general observations and some seining in the East Koy the fantail appeared to be much less common than each of the four species of

cyprinids listed above for these areas.

While the darter diet of these fingerling bass may not be associated with any selectivity, it might be strongly related to benthotic feeding habits and the relative number present on the bottom. Many young cyprinids were observed in the two sections, but these were not frequently taken. The crayfishes, fantail darters and aquatic insects which formed most of the bulk of food for the young bass were principally organisms that live on the bottom.

Of interest in this study is the use of quantitative data of fish populations of streams determined by the use of the electric shocker. This method has become an important tool to fisheries biologists today, in qualitative as well as quantitative sampling of the fish fauna, but has certain limitations. As pointed out above, it may not be very effective in sampling certain small percid fishes, especially in streams of mixed gravel and rubble bottom. The efficiency of recovery of shocked, marked legal trout in small tributary streams of central Pennsylvania varied from 90 per cent in streams of gravel-clay bottoms to only 40 to 60 per cent in rubble bottom streams. In certain trout waters with a heavy autumn growth of water cress, *Nasturtium officinale*, efficiency tests were about 50 per cent, while in the spring of the year, tests in the same waters resulted in a considerably higher percentage of recovery. Stream size, depth, and turbidity may cause additional variations in efficiency. There was considerable variation in numbers of forage fishes taken by electric shocker (Table 3) in the two sections which were separated by about ½ mile.

SUMMARY

1. A total of 248 young northern smallmouth bass were taken from two 100-yard stream sections from the East Koy Creek, a tributary of Genesee River, Wyoming County, New York on August 11 and 12, 1941. Their mean standard length was 52 mm. with a range from 32 to 78 mm. The platykurtic nature of the length-frequency distribution was evidenced by the large standard deviation of 12.12 mm.

2. Of 248 stomachs examined 222 contained food. Aquatic insects, crayfishes, and fishes formed the bulk of food eaten. Of these food items, nonburrowing Ephemeroptera of the families Heptageniidae and Baetidae, *Cambarus*, and the barred fantail darter, *Poecilichthys f. flabellaris*, were most frequently taken and formed the greater percentage of the volume of all food eaten.

3. The type of food taken was associated with size of the bass. Few insects were eaten by bass over 60 mm. Only 1 crayfish was found in specimens under 50 mm. and no fishes were eaten by those under 40 mm.

4. Although four species of Cyprinidae represented the most abundant forage fish population as revealed by electric shocker sampling method, these were not commonly eaten. The barred fantail darter apparently formed a small percentage of the creek population (less than 2 per cent by electric shocker sampling method) but made up about 50 per cent of the number of all fishes eaten.

5. The large number of aquatic insects, crayfishes and darters in the food of fingerling bass may be associated with benthotic feeding habits.

The writer wishes to thank Dr. Udell B. Stone, New York Conservation Department for making available certain data.

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METHODS FOR DETERMINING THE AGE OF GAME BIRD EGGS

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INTRODUCTION

For various purposes it is of interest for the game biologist as well as the practical wildlife manager to be able to determine the age of the eggs in game bird nests, and thus to be able to calculate the dates of egg-laying, initiation of incubation, critical stages during incubation, and hatching.

McCabe and Hawkins (1946: 34–42) have worked out the embryological development of the European partridge, and Eugene H. Dustman (unpublished) is making a similar study of the embryology of the pheasant. The investigation of the embryo, necessitating the opening and thus the destruction of the investigated eggs, requires rather great skill on the part of the investigator, reference tables for the species concerned, and description, measurements and weights of the embryos.

It therefore seemed desirable to devise a method which, without destroying the egg, would make possible a quick and easy age determination without

[1] The Ohio Division of Conservation and Natural Resources, the Ohio State University, the United States Fish and Wildlife Service and the Wildlife Management Institute cooperating.

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requiring too much technical knowledge and apparatus.

For a number of years I have used the method of putting eggs in water in order to test their age. This was done especially when visiting gull and tern colonies and waterfowl breeding grounds in my home country, Denmark. If the eggs rested horizontally or stood more or less on the pointed end on the bottom of the water they were assumed to be fresh or incubated less than a week. I had never done any research to test the accuracy of this assumption.

During the summers of 1947 and 1948 I had the opportunity to test this and other methods, naturally correlated with it, as most of them relate to the growth of the air cell and loss in weight, mainly in pheasant and European partridge.

Although it is believed the same methods can be used for other species of game birds, it would seem desirable for field workers beginning life history studies of game birds to work out the egg age determination methods best suited for their particular species and publish the results, so repetition of work might be avoided.

METHODS

A total of 141 pheasant eggs and 42 European partridge eggs were incubated during the two summers in a round electric incubator with a capacity of 100 eggs. The instructions of Romanoff (1934) were followed concerning incubation temperature and relative humidity.

The eggs were divided into groups in order to have representative data for various age classes of eggs in a nest. When incubation starts in a pheasant nest the freshest egg is newly laid, the oldest egg is 12–15 days old. For that reason the eggs were divided up into six groups, namely 0, 3, 7, 9, 11 and 15 days old on the day they were put in the incubator.

The eggs were weighed daily, and tested in water for angle, portion protruding and movements. The specific gravity was taken by placing eggs in graduated cylinders. This work was carried out simultaneously for each group of eggs. Lukewarm water (about 100°F) was used in testing the eggs.

UNINCUBATED EGGS

The first question is whether the eggs are incubated or not. As mentioned later under "Egg Weight," a certain change takes place even in unincubated eggs, causing a slight loss in weight and hence a raised position in water. These changes, however, are so small that they are not readily measurable and thus not very applicable in a practical method.

The habit of some game birds of covering their eggs during the egg-laying period, but not when leaving the nest during the incubation period, provides a way of telling whether the eggs are being incubated. European partridge hens cover their eggs with nesting material and vegetation during the egg-laying period, but the eggs are left exposed when left by the bird during incubation. About wild turkeys Mosby & Handley (1943: 113) state: "The laying and incubating hen frequently covers her eggs when leaving the nest."

Another distinction indicating whether incubation has begun in a nest is the position and the cleanliness of the eggs. Stoddard (1946: 26) describes this

for the bobwhite quail: "A nest in which eggs are accumulating can usually be told by the way the eggs are piled up. If incubation has started they are in one layer as a rule, and have a slightly glossy texture. The eggs are rearranged to a slight extent each time the hen lays, the eggs of the preceding day at least being rolled down out of the way with the beak. During the laying period, they are not methodically turned as a general thing, and in wet weather they soon accumulate characteristic yellowish stains on one side from contact with the nest material."

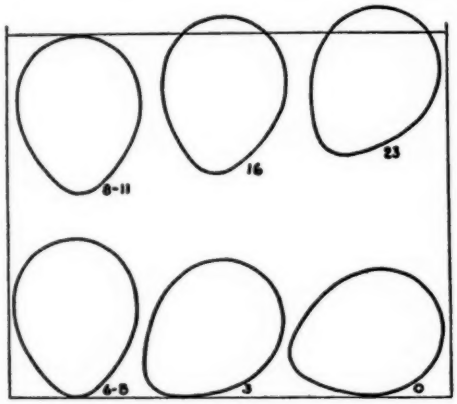

FIG. 1. The change in position of an incubated pheasant egg when put in water. Numbers indicate day of incubation.

DEVELOPMENT OF AN EGG

The various factors worked with in order to find usable egg age determination methods concern the weight loss due to evaporation and the growth of the air cell.

The air cell is situated between the two layers of the parchment-like shell-membrane at the broad end of the egg. During incubation, evaporation of water and of gases in addition to expired carbon dioxide by the developing embryo causes a gradual loss of weight of the egg. The shrinkage and solidification of the egg contents into a chick in addition to the evaporation result in a gradual growth of the air cell.

EGG POSITION IN WATER

The factors which make the water test possible are the growth of the air cell, weight loss, and at a later stage of incubation movements of the developing embryo within the egg. The gradual growth of the air cell causes the egg to turn over from an almost horizontal position on the bottom of the water to a vertical position, standing on the pointed end; next floating up to the surface, with more and more of the blunt end gradually protruding above the water, and also slowly changing the angle; from the 17th day of incubation (pheasant) movements of the egg in water can be seen, and finally pipping of the egg occurs on the day before hatching (Fig. 1).

When the individual eggs are traced this method works with a high degree of exactness; but when all the collected data are combined, covering from small to large-sized eggs and newly laid eggs and eggs up to 15 days old, considerable overlapping occurs. It was found, however, that when the size of the eggs was taken into account the error was diminished somewhat.

As mentioned under the section "Weight Loss," evaporation normally takes place even in unincubated eggs, and causes a slight growth of the air chamber resulting in a slow increase in egg-angle in water. This rise of the egg in water is so slight, however, within the normal egg-laying period, that the effects of age even for the first laid eggs

are eliminated with the first day of incubation. The angles assumed by the eggs of European partridges are indicated for different egg ages in Table 1.

TABLE 1.—CONDENSATION OF FINDINGS SHOWING APPROXIMATE AGE OF UNINCUBATED EGGS OF EUROPEAN PARTRIDGE BY TESTING EGG-ANGLE IN WATER

TESTING EGG-ANGLE IN WATER	
Egg Angle	Age of Eggs in Days
8–16°	1– 7
17–24°	8–16
25–32°	17–21
33–40°	22–25

Because of the fact that unincubated eggs also showed an increase in egg-angle when tested in water, six groups of pheasant eggs were used in this study, namely eggs being respectively 0, 3, 7, 9, 11 and 15 days old when incubation started. Also small, medium and large sized eggs were distributed in the various groups as well as possible.

The egg-angles as found for pheasant eggs within the first week of incubation are shown in condensed form for practical use in Fig. 2.

It will be noted that the pheasant egg rises from the bottom of water to a vertical position, standing on its pointed end, within the first six or seven days of incubation. As a rule-of-thumb it might be said that the unincubated egg or egg on which incubation has just started lies almost horizontal; the egg incubated for three days stands at a 45° angle; and the six to seven day old egg stands vertically on its pointed end when placed in water.

The next phase is the rise of the egg to the surface of the water, taking place when the specific gravity of the egg becomes less than that of water.

Some eggs remain at a 90° position on the bottom for several days, whereas other eggs rise on the same day the 90° position is attained; a few eggs do not reach the 90° angle bottom position but may rise from angles of about 85°.

This variability in the movement of eggs to the surface of water occurs over a period from the 6th to the 14th day

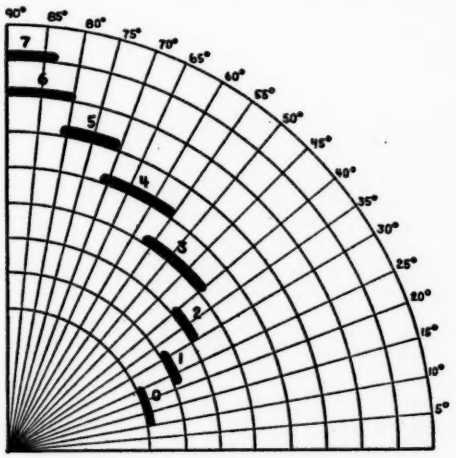

FIG. 2. Increase in egg-angle in pheasant eggs tested in water during the first week of incubation. Large numbers indicate day of incubation.

of incubation as extremes, but 58 per cent of the eggs were found to rise on the eighth to the tenth day of incubation.

Small eggs rise earlier than large eggs. Eggs weighing about 30 grams rise to the surface of the water from the sixth to the tenth day of incubation; middle-sized eggs (around 35 grams in weight) rise from the seventh to the eleventh day of incubation; and large eggs (around 40 grams in weight) rise to the surface of water from the ninth to the twelfth day of incubation.

Another factor affecting the time for rise of the egg is the age of the egg when incubation started. In a nest found in nature the age of the individual eggs is

not known, of course, but from the controlled experiments it appears that the older the eggs are when incubation begins, the earlier they rise. Eggs newly laid when incubation started thus rise to the surface of the water between extremes of the ninth and fourteenth day of incubation, whereas eggs 11 days old when incubation started rise between the sixth and eleventh day of incubation.

The egg, at first, hangs at the surface of the water, barely touching it, and barely visible above the surface. It gradually protrudes more and more, but remains at about the same angle, namely between 83° and 90°, until the 20th day of incubation when it starts turning over. The average egg-angles for the last days of incubation in pheasant eggs are as follows: 20th day 81°; 21st day 77°; 22nd day 71°; 23rd day 59°.

The egg gradually protrudes more and more above the water, from about 10 mm. when it first comes up, to about 29 mm. when ready to hatch. This increase in diameter of part of the egg above the water is shown in Table 2. It will be remembered that the rise of the egg extends over several days causing some overlapping in the figures, but it may be said that the error decreases the more incubation is advanced.

The weakest part of this age determination method is from the time the egg rises to the surface of water (the 8th to the 10th day) until the 17th day of incubation.

An egg which protrudes more or less above water, and which does not move at all in water can be said to be 10–17 days old; if the protruding portion of the egg is about the size of a one cent coin it has been incubated for 10–12 days; if about the size of a 25 cent piece the egg is 15–17 days old. Unfortunately much overlapping occurs.

On the 17th day of incubation the first movements of the eggs in water can be seen; I had one case where slight movements of the egg were visible on the 16th day. At intervals small jerks in the egg make it move a little in the water. Often one has to wait for a little while as the movements as mentioned occur at intervals.

TABLE 2.—DIAMETER OF PART OF PHEASANT EGG PROTRUDING ABOVE WATER DURING VARIOUS STAGES OF INCUBATION

Day of Incubation	Number of Eggs	Diameter in mm. of Part of Egg Protruding
9	14	14.8
10	20	16.3
11	26	17.5
12	33	19.3
13	35	21.3
14	35	22.3
15	35	23.7
16	35	24.7
17	35	25.6
18	34	26.1
19	30	27.1
20	24	27.2
21	24	28.4
22	28	28.8
23	13	29.0

The movements of the egg increase slightly in intensity, but not until the 21st day are the movements so strong that the egg actually jerks and moves intensively, but still at intervals.

Pipping of the eggs occurs on the 23rd day of incubation, and the hatching takes place the following day or perhaps the same day. Sometimes the eggs hatch on the 22nd day. The length of incubation is variable and depends upon temperature of the incubating hen, fluctuations of the air temperature,

length of time the hen is away from the nest, nest site and other factors.

Pheasant eggs are usually pipped from 12 to 24 hours before hatching. Before the pipping is visible the chick can, at intervals, be heard tapping on the inside of the shell. When an egg incubated 21 to 23 days is laid on a piece of smooth, hard material (a book, table, scales) the movements of the embryo in the egg will cause it to jerk and move.

WEIGHT LOSS

A bird egg loses weight gradually before incubation starts, and still more during incubation. The changes in the unincubated egg of the domestic fowl are discussed in detail by Romanoff and Romanoff, pp. 654–689.

The loss in weight in the unincubated egg is very little and is due to evaporation of water through the pores of the shell. The rate of loss is increased with increasing temperature and decreasing humidity.

Normally a pheasant egg would not remain unincubated in a nest for more than 15 days, most of the eggs only for a shorter period. Four eggs were kept in an icebox for 15 days at 55°F. They weighed on the day of laying and 15 days later respectively:

32.4 grams	32.2 grams
31.2 grams	31.1 grams
38.6 grams	38.4 grams
39.4 grams	39.3 grams

The average loss per egg for the 15 days was 0.16 gram or approximately 0.01 gram per egg per day.

Five pheasant eggs were kept in a thermograph in the open to test their reaction to fluctuating summer temperatures. Their weights on June 16 and 26, 1948 respectively, were:

34.3 grams	33.7 grams
31.0 grams	30.5 grams
31.9 grams	31.0 grams
34.8 grams	33.6 grams
31.0 grams	30.1 grams

The average loss per egg for the 10 days was 0.81 gram or 0.08 gram per egg per day. Thus the loss in weight in this latter group was eight times greater than in the first mentioned group, and was due to the much higher temperatures, ranging between 48°F. and 96.5°F.

The temperatures during this test in June were higher than in spring when egg-laying of pheasants usually takes place, so the loss in weight during the normal egg-laying period may be less. Late clutches may, however, be exposed to similar high temperatures.

The loss in weight in the incubated egg is rather stable as it will appear from Table 3. The weight loss might thus be used as a rather reliable indicator of the stage of incubation of the eggs in question. Because of the great difference in size of pheasant eggs it is necessary to know the individual weights of the fresh eggs in order to determine their age.

The weight of the fresh egg may be approximated from its measurements.

Various methods for this purpose have been described. Schönwetter (1924) proposed the formula $W = \frac{1}{2}(LB^2 + w)$, in which W is weight of the egg, L is length of the egg, B breadth of egg, and w is the weight of the egg shell. This formula cannot be used in this connection as the weight of the egg shell is not at hand.

Bergtold (1929) developed the formula $W = 11/21(LB^2)S$, where the symbols are the same as above, and S stands for the specific gravity of the fresh egg. When the specific gravity is known for a

species the formula might be simplified by reducing $11/21 \times S$ to one factor. The average specific gravity for a pheasant egg was found to be 1.075, the same as Bergtold (l.c., p. 468) found for chicken eggs. The formula was thus altered to: $W = 11/21.5(LB^2)1.075$, which can be reduced to $W = (LB^2)0.55$. The error is less than one per cent in average; the maximum error is two per cent.

TABLE 3.—WEIGHT LOSSES AND STAGE OF INCUBATION IN PHEASANT EGGS. WEIGHT IN GRAMS

Day of Incubation	Weight of Egg	Daily Weight Loss	Total Loss in Weight
0	32.9	—	—
1	32.5	0.4	0.4
2	32.3	0.2	0.6
3	32.1	0.2	0.8
4	31.8	0.3	1.1
5	31.5	0.3	1.4
6	31.2	0.3	1.7
7	31.0	0.2	1.9
8	30.7	0.3	2.2
9	30.4	0.3	2.5
10	30.2	0.2	2.7
11	29.9	0.3	3.0
12	29.7	0.2	3.2
13	29.4	0.3	3.5
14	29.1	0.3	3.8
15	28.9	0.2	4.0
16	28.7	0.2	4.2
17	28.4	0.3	4.5
18	28.2	0.2	4.7
19	27.9	0.3	5.0
20	27.7	0.2	5.2
21	27.4	0.3	5.5
22	27.1	0.3	5.8
23	26.9	0.2	6.0

To determine the age of an egg, in this case a pheasant egg, measure it carefully to the nearest tenth of a millimeter with a sliding caliper, insert the measurements in the formula: $W = (LB^2)0.55$ and the result will be the weight of the fresh egg.

Next weigh the egg on a scale to the nearest tenth of a gram, and subtract the actual weight of the egg from the fresh egg weight found by the formula. The difference in grams is the loss in weight from the time incubation began. Compare the difference in weight with the data in Table 3 and thus determine the corresponding age of the egg.

As it will be seen from Table 3, the loss in weight averages about 0.3 gram per day and is correspondingly higher in larger eggs and less in small eggs. Eggs weighing less than 30 grams when fresh lose 5.4 grams in weight up to hatching, and eggs weighing more than 36 grams when fresh lose 7.1 grams up to hatching compared with a loss of 6.0 grams for normal eggs (31–35 grams fresh weight).

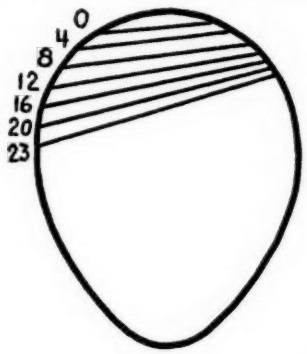

FIG. 3. Growth of air cell in a pheasant egg during incubation. Lines indicate four-day intervals, and numbers day of incubation.

The loss in weight in an incubated egg is inversely proportional to the amount of humidity present (Romanoff 1934). The smallest loss in weight is found at high humidity and the greatest loss at low humidity. The daily loss in weight of pheasant eggs as found by Romanoff (1. c., p. 26) varies from 0.169 gram at 80 per cent relative humidity to 0.271 gram at 40 per cent relative humidity. This variation in daily loss in

weight might be well to have in mind, as eggs taken from nests in extremely humid or dry locations might cause a loss in weight differing somewhat from the average figures given in Table 3.

CANDLING: GROWTH OF AIR CELL

The gradual growth of the air cell of the incubated egg can be used with a fair degree of accuracy in determining the age of an egg. Candling of eggs

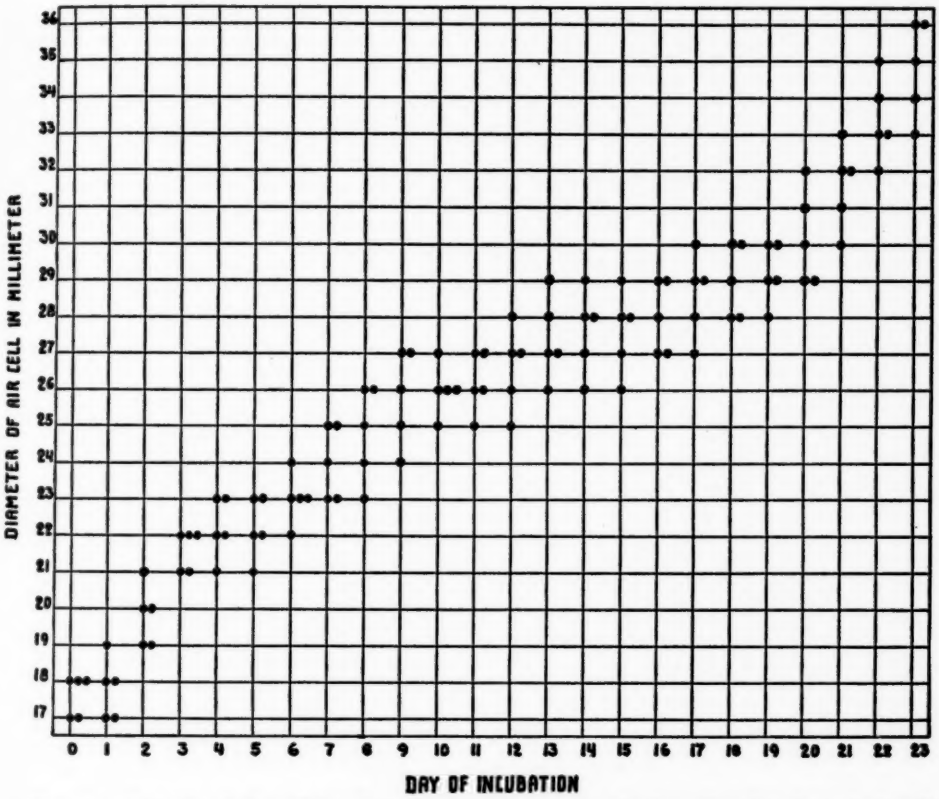

FIG. 4.—Growth of air cell in pheasant eggs during incubation. Overlapping of air cell sizes can be minimized by figuring in the size of investigated eggs; maximum width of egg 39 mm.; medium width 37 mm.; minimum width 35 mm. Large eggs occur on the left, small eggs on the right for each diameter given.

These figures are thought, however, to be valid for general purposes; extremes can never be made to fit into a general practical guide.

As a rule-of-thumb it might be said that an average pheasant egg loses one fourth of a gram per day during incubation.

(chicken, duck, goose, and game bird eggs) has been known and used for a long time, but usually to determine whether the eggs are fertile or not, or whether embryos are dead within the eggs. Candling of eggs might be used as an aid in determining the age of eggs, too. The larger the egg, the better the

method will work. Eggs of the European partridge are well below the minimum size for eggs usable for age determination by this method. Pheasant eggs can be aged with fair accuracy by this method.

The candling of game bird eggs in the field is a rather difficult procedure. The eggs must be candled in a dark room,

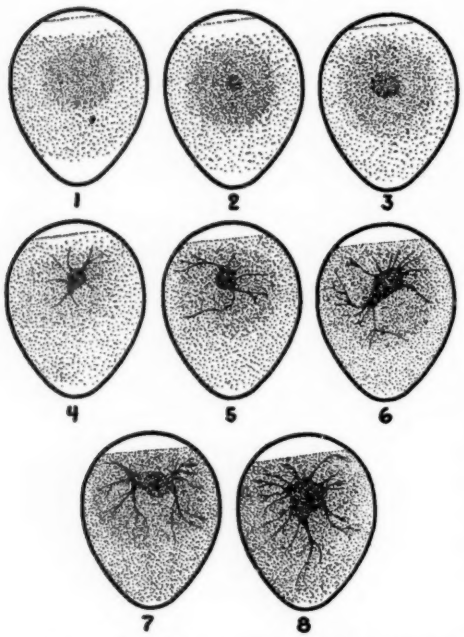

FIG. 5. Candled pheasant eggs during the first week of incubation. From the ninth day the egg is dark and opaque.

or a special candling box must be carried around; the method is practical only with large sized eggs; and effective candling is difficult when checking thick-shelled or dark-coloured eggs.

The development of the air cell of a pheasant egg is shown in Fig. 3. The figure gives an idea about the approximate size of the air cell at various stages of incubation. The diagram, Fig. 4, shows the daily growth of the air cell of pheasant eggs for the whole incubation period. The age of the egg when incubation began proved to be of little importance in this connection, as the daily growth even during incubation is very slight, less than a millimeter on the diameter per day.

The graph shows that the overlap, especially during the middle part of the incubation period, is rather great. The greatest overlap for each size of egg cell diameter is nine days; the smallest error zero; the average error for the whole incubation period is 3.3 days, or 14 per cent.

The average as well as the maximum error seems to be too great for a practical use of the graph, but the method is better than it appears from the graph, if the size of the egg is taken into consideration. Checking of the eggs used in the study showed that large broad eggs have comparatively larger air cells than smaller eggs at the same stage of incubation. For that reason and for better use of the graph, small, medium and large egg widths are given in the legend under Fig. 4. The figures are not true extremes for size, but averages in each category usable for this purpose.

The use of the egg width (measured with a sliding caliper, or after some experience only by looking at the egg) narrows the error down appreciably; the maximum error is decreased to about three days, and the average error is only one day. If a few eggs from a nest are tested the average age found can be taken if the results vary.

CANDLING: GROWTH OF EMBRYO

The growth of the embryos as seen by candling is usable only during the first week of incubation. Fertile eggs

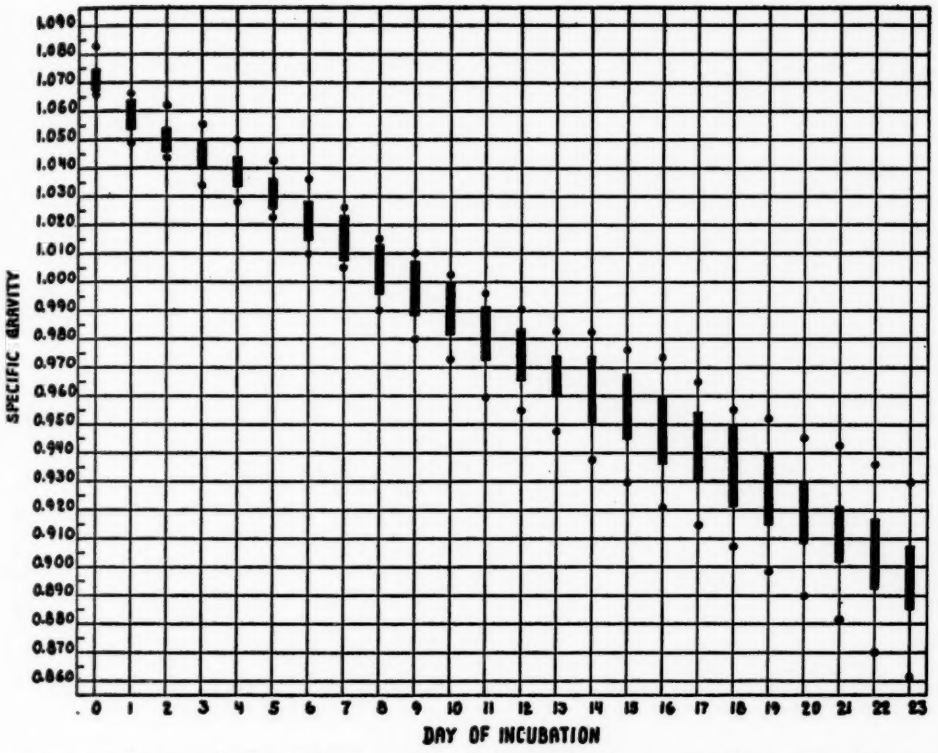

FIG. 6.—The specific gravity in pheasant eggs during incubation. The heavy lines indicate that 50 per cent of the eggs investigated fall within the limits indicated; dots represent extremes.

become completely dark and opaque on the ninth day of incubation, and stay so during the rest of the incubation period.

The development of the embryo of pheasant as seen by candling is shown in Fig. 5. The age of eggs at one of these stages can be determined with a fair degree of success by the figures. After the ninth day of incubation, when the egg is dark, the size of the air cell can be used in the age determination.

SPECIFIC GRAVITY

By working with the specific gravity the necessity of considering weight loss for the individual eggs is eliminated, as the specific gravity is a constant ratio between egg weight and egg volume.

An attempt was made to devise a formula by which the specific gravity of eggs could be calculated with a high degree of accuracy.

Various formulas were tried, and finally Bergtold's original formula $(LB^2)11/21$ without the value for the specific gravity included, was used to determine the volume of the egg. Instead of 11/21 again 11/21.5 was used. This formula reduces to: $V=(LB^2)0.51$, where V=volume of egg; L=length of egg in millimeters; B=breadth of egg in millmeters. The volume of the egg in cubic centimeters is divided into the weight of the egg in

grams to determine the specific gravity.

From the graph, Fig. 6, the stage of incubation can be read, corresponding to the specific gravity.

As the volume of the egg does not change during incubation, and as the daily weight loss is rather constant, the specific gravity accordingly decreases at a rather stable rate.

Data for specific gravities of investigated pheasant eggs, representing extremes and averages are compiled for practical use in the graph, Fig. 6. The overlap is slight the first week of incubation, after which it increases so much that the method cannot be recommended for the latter half of the incubation period. A general use of the specific gravity as an age indicator in birds' eggs is therefore not possible.

DETERMINATION OF TIME OF EGG-LAYING

When the age of the eggs is determined it may be desired to determine the date of laying of the first egg in the nest. The procedure is to count the eggs in the nest, multiply it with the egg-laying rate factor, and then count the corresponding number of days back from the date of investigation.

The egg-laying rate is not known for all game birds. For the European partridge the author found the egg-laying rate to be 1.34 day per egg, based on records for 624 Danish eggs. Ogilvie (1925) found it to be 1.43 day per egg in England; and McCabe & Hawkins (1946: 21) give 1.1 day per egg in Wisconsin.

Data on the egg-laying rate of the pheasant can be taken from Shick (1947: 305); 111 eggs were laid by 7 hens in 155 days, giving an average egg-laying rate of 1.4 day per egg.

SUMMARY

Experiments were carried out with eggs of the pheasant and European partridge in order to devise a method for determining the number of days incubated. The methods proposed herein are based largely on observations of pheasant eggs.

Nests where incubation has not begun yet can often be recognized by an incomplete clutch; the eggs are cold; the eggs are often stained and are piled up in the nest; and in some species, e.g. the European partridge, by covering of the eggs.

The factors in the development of an egg making age determinations possible are the weight loss due to evaporation and the accompanying growth of the air cell.

The several methods of determining stage of incubation are described in detail, together with their limitations and uses: testing the egg in water; measure of weight loss; candling; and use of specific gravity.

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A FAMILY TYPE LIVE TRAP, HANDLING CAGE, AND ASSOCIATED TECHNIQUES FOR MUSKRATS[1]

I. Edwin Snead

Iowa State Conservation Commission

During a muskrat (*Ondatra zibethica*) investigation on the Mississippi River at Lansing, Iowa, considerable effort has been directed towards the live trapping and tagging of muskrats. Incidental to the progress of the investigation a family type live trap, handling cage, and some techniques relating to their use were devised.

Most commercial or hand-made live traps used for capturing muskrats consist of a wire or wooden box with various arrangements for closing a trap door over one or both ends. Others work on the principle of a cage-like lid which falls over the muskrat, or a set of caged jaws which close up around the animal. All probably have certain

[1] The work was undertaken by the Iowa State Conservation Commission with Federal Aid to Wildlife Restoration funds under Pittman-Robertson Project 6-R. Thanks are due Mr. Alvin Iverson, Iowa State College, for field assistance during the summer of 1947. Acknowledgment for cooperation is due Mr. Ray Steele and personnel of the Upper Mississippi River National Wildlife Refuge, on which area the investigation was conducted, and to personnel of the Iowa State Fisheries Station at Lansing, Iowa. Special acknowledgment is due Dr. Thomas G. Scott, formerly of the Iowa Cooperative Wildlife Research Unit and Dr. Paul L. Errington, Iowa State College, for general counsel and many services.

advantages and disadvantages involving cost, simplicity of construction, transportability, physical well-being of captives, adaptability to specific habitats, purpose for trapping, and primarily—efficiency in catching muskrats. Furthermore, variation in proficiency of individual operators may cause a considerable discrepancy in the degree of success with a given trap. It would seem then, that a comparison of the merits of a particular trap against those of another, on a broad basis, may be subject to some rather obvious limitations.

The trap herein described is an outgrowth of the old under water box trap or "stove pipe" trap formerly used with remarkable efficiency by commercial trappers on the Mississippi River. Lantz (1923, p. 14) makes brief mention of such a trap, stating that it was "a favorite with some trappers."

Now illegal in Iowa, these traps varied somewhat in dimensions and construction materials but employed the same basic design and working principles. In general, they consisted of a short tube with inverted wire gates at each end that swung inward but not outward. The tube was usually square or rectangular in cross-section and constructed of sheet metal or wire netting; however, quickly made though probably less efficient models simply employed a section of stove pipe. The gates were hinged at the top inside the ends of the tube. The vertical measurement of each gate was greater than that of the tube, thus causing the gate to rest at an angle. This simple swinging door pushed upwards to admit an incoming muskrat and dropped back down after its passage. The square or rectangular cross-sectional design facilitated smooth action of the end gates and added other advantages. The trap was placed under water within the trenches or runways of the muskrats. Because muskrats could enter the trap from either end they were caught "coming and going." Trapped rats were drowned within a few minutes, minimizing suffering and eliminating loss from "wring-offs" so common with the use of steel traps. According to reliable reports, very commonly all the muskrats within a burrow were caught in short order, or the traps become filled to capacity with drowned animals. Muskrats that escaped were uninjured and subject to re-capture, possibly from the same burrow.

It is suggested that this trap, where legal, may still be of considerable value to wildlife workers and others for certain experimental or control operations. It should be well adapted for collecting dead muskrats in an unmarred physical condition and, because of relatively quick death with contents of the alimentary tracts essentially unchanged. Such traps might be used inconspicuously to remove nuisance muskrats from dikes, city park ponds, water reservoirs, and fish hatchery ponds. All traps would be under water with drowned catches enclosed within, and for all practical purposes obscured from the public eye. Furthermore, the traps would need to be inspected less frequently than steel traps because of the drowning and multiple catching features. The limitations of the trap would be essentially the same as some of those to be discussed in connection with the live traps.

THE FAMILY LIVE TRAP

In August, 1946 several galvanized metal underwater box traps which had

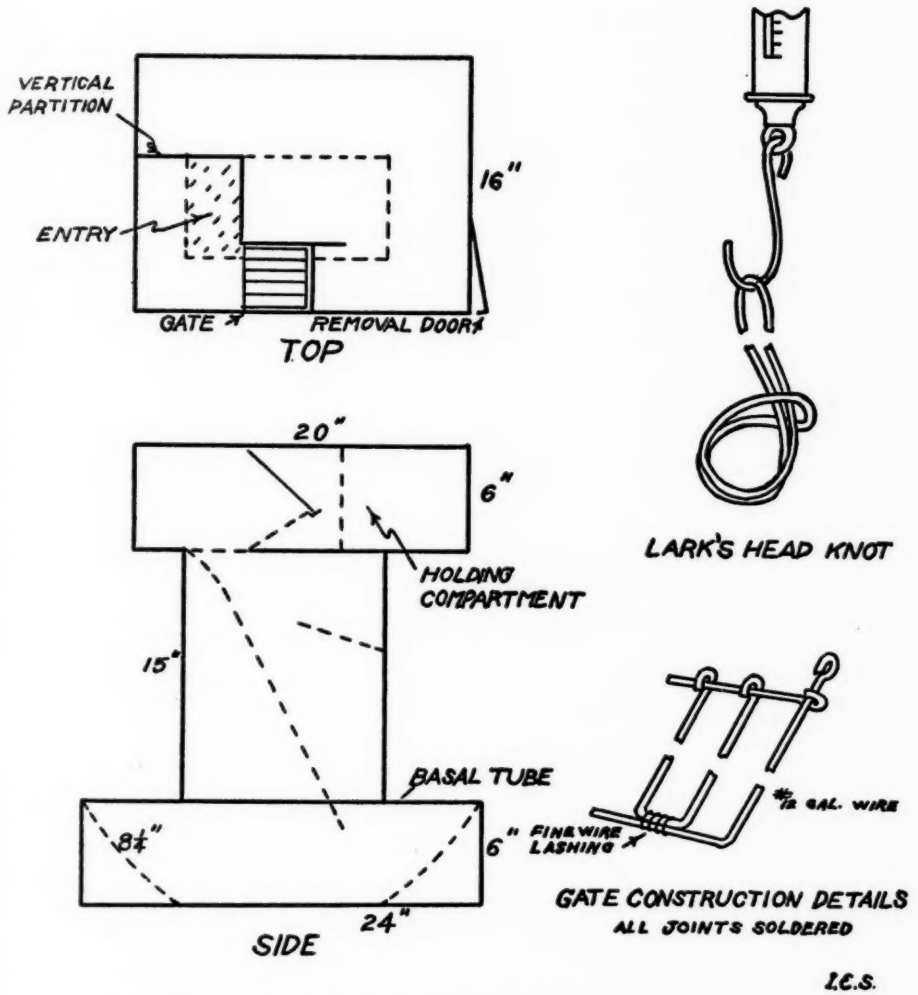


FIG. 1.—Family trap for muskrats and weighing device.

been held in storage were acquired. Walter J. Bailey, a local trapper and seasoned "riverman," furnished many helpful suggestions regarding modification of the traps for preserving the catch alive. The first live traps were constructed by cutting away a good part of the upper surfaces in the mid-portions of two of these original traps, and superimposing rectangular hardware cloth cages. Platforms within the cages furnished resting places for the captives above the surface of the water when the traps were set. Trials met with immediate success in catching muskrats, but considerable mortality resulted from crowding and persistent attempts by the animals to escape under water. Experimentation with design and further trials led to construction of sloping runways leading from the water to an enlarged platform and

cage at the top. The mortality factor continued to be objectionable, however, if the traps became crowded. Finally with the insertion of a one-way gate at the entrance to the enlarged top compartment, which served as what may be termed a "holding compartment" together with improved trapping practices fatalities were reduced to a very small amount. During the course of construction and improvement, traps of several sizes and shapes were made and employed. All operated on the same basic principle, and after final modification with about the same degree of efficiency, excepting for adjustment of the traps to water depth.

Details of a trap judged most likely to be well suited to average conditions are illustrated in figure 1. The cage was constructed of half-inch mesh hardware cloth. One-inch mesh welded wire fabric, which has become more readily available on the market since the time when the traps were constructed, probably offers an advantage over hardware cloth because of greater resilience. The woven wire portion is soldered to the 24-gauge galvanized sheet metal base. The seam of the basal portion may be overlapped and riveted, or a standard locked seam may be made by a tinsmith.

It is desirable to cover the top and sides of the holding compartment, except for the area around the entrance gate with a double layer of corrugated cardboard. The cardboard may be bound in place by a few strands of small gauge wire. The covering affords partial protection against exposure to extremes of weather. The entrance area is left uncovered in order to discourage muskrats from crowding or building nests there, thus blocking the gateway. After initial escape attempts most animals seek the shaded interior of the covered portion.

The three swinging gates, though simple, should be constructed and fitted into the trap with care (Fig. 1; Pl. 1, B and C). It is important that the lower edges of the gates fit flush against the bottoms of the entrances. Since muskrats are reluctant to push through heavy gates, these should not be made with larger wire than number 12 gauge. On the other hand, it is desirable that gates be strongly made in order to withstand the attacks of the trapped animals. A hard grade of wire will prove superior to the heavily annealed grades.

The cut-away portion at the top of the sloping ramp (Pl. 1, C) should not be overlooked. It provides a portal for muskrats ascending the cage other than by the ramps. Without it, captives may occasionally be drowned through inability to find their way out of the pocket formed under the ramp. The traps should be given one coat of dull paint to reduce light reflection from the metal and waterproof the cardboard cover.

TRAPPING TECHNIQUES

The traps are primarily adapted for use at bank burrows, or at houses in shallow water areas. They are also most effective during the production period, when family groups are more or less closely associated at a home site. Water depths from the bottoms of the runways at the habitation entrances should not exceed the height of the trap up to within one or two inches of the floor of the holding compartment, assuming of course no anticipated rise of water level. The height to which traps are constructed would therefore depend upon the average water depths at burrow

entrances in the locality or type of habitat to be trapped. On the backwater areas of the upper Mississippi River, variation in water depths at den or house sites is considerable; however, most situations could be effectively handled with traps having a 15-inch clearance between the basal tube and the floor of holding compartment. For trapping at burrows with water depths too great for such traps, and for use when higher than usual water levels prevailed, three somewhat modified traps were made. These had telescoped mid-sections by means of which the traps could be extended to correspond with water depths up to four feet. The middle portions might be described as of two separate rectangular hardware cloth sleeves, one fitting within the other. The outer member is attached to the basal tube of the trap, while the inner member, containing the usual sloping runways, is secured to the holding compartment. The trap is locked in position at the desired height by placing two heavy wire skewers horizontally through the meshes in the region where the members overlap.

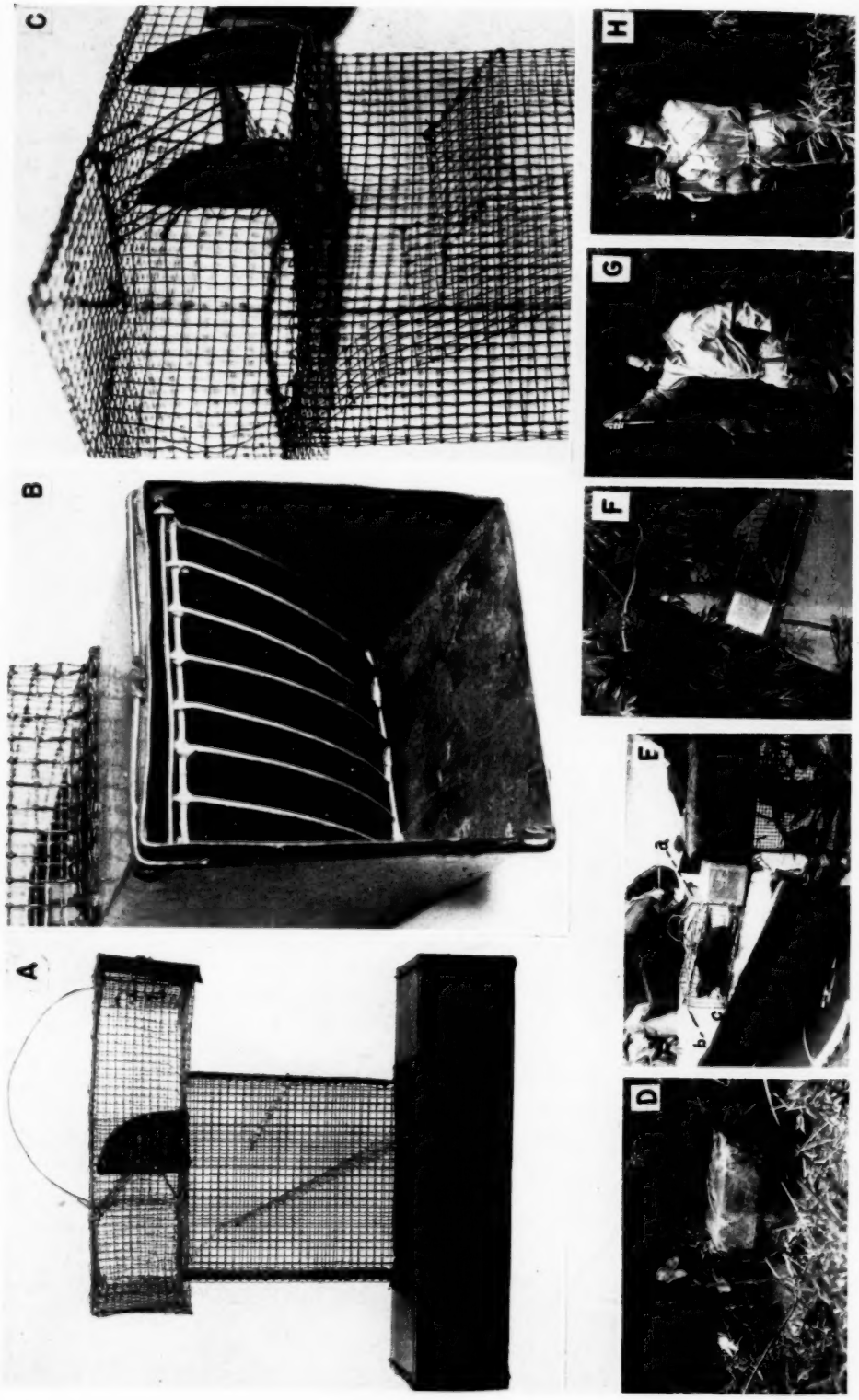
Brief comment on the swimming habits of muskrats when entering or leaving burrow openings, and a word or two about the structural aspects of runways leading from entrances are perhaps of value in understanding how the traps function and the technique for setting them. A muskrat leaving or approaching a burrow entrance usually swims with fore parts lowered and close to or in frequent contact with the bottom. Presumably they often feel their way along with the fore feet, and especially so if the water is roiled. Travel lanes connecting with burrow entrances usually assumed the form of trenches or depressed runways of various depths and lengths. In general, shallow water and low bottom gradients at a den site, plus continued occupancy, were associated with relatively deep and long runways leading to deeper water. This relationship partly resulted from the customary sequence of water level changes during the breeding season, characterized by relatively high stages at the start with continued or interrupted subsidence as the season progressed. The animals ordinarily deepened and lengthened runways as water levels lowered. Reactions would seem in many respects to have been similar to certain of those described by Errington (1939, pp. 180–181) in connection with conditions of drouth in Central and Northwestern Iowa, although the two situations as a whole were largely dissimilar. With steep bottom gradients, deeper water, or short-time occupancy, a reverse situation tended to prevail. But in most situations the habits of the animals to move along definite travel lanes at bottom level in the vicinity of burrow openings caused them to slip under the swinging gates of a properly set trap. Active runways usually were swept somewhat free of the finer silt, and typically were noticeably more firm near the openings than the surrounding bottom. It became customary for the operator to feel for the bottom of runways with his booted foot, and to take into consideration recency of food cuttings and other "signs," if doubt existed as to use. Frequently active runways were distinguishable by muddy streaks in the water as a result of roiling by movements of muskrats along them, or because of activity within a burrow system.

Traps were placed within the runways so that one end fitted flush with the burrow entrance, or even extended into it. An important detail was to make sure that the bottom of the trap at both ends lay close to the bottom of the runway. Sometimes it was necessary to modify the shape of the runway, by straightening it for the length of the trap, or by scooping out the bottom. This could usually be accomplished with a piece of board, a small narrow shovel, or similar tool. When the need for considerable modification of the runway was indicated, or if heavy tree roots or other hampering circumstances prevented the trap from fitting up against the burrow opening, the trap was placed as near to the opening as was practical.

The traps were propped in an upright position by two short sticks placed at angles against the sides. Very often runways were considerably wider than the base of the trap, or were "V" shaped, so as to present escape routes. Such a condition was quickly remedied by pushing one or more short boards into the mud. These were placed at the ends of the trap, and at an angle to the same, so as to funnel the swimming animals towards the trap entrances. Slats from orange boxes or most any wooden packing crate are quite satisfactory for the purpose. Frequently pieces of drift wood, chunks of root-bound soil, or other materials readily available at the den site were employed in like manner to block off portions of a runway. If the water in a runway at a den entrance was not sufficient to completely cover the basal tube (as was often the case after lowered water levels) little or no catch was likely, and the traps were consequently moved to a portion of the runway with suitable depth. Similarly, if only an inch or two of water covered the basal part of the trap, a handful or two of vegetation placed on the water surface a few inches away from each end of the trap proved helpful. It is probable that such surface obstructions helped assure underwater movements along shallow runways in the trap vicinity and aided concealment of trap entraces.

Possibly the most common causes of fatalities to small mammals in live traps stem from overexposure to excessive heat or cold under unnatural conditions. Directly bearing on the matter may be the length of confinement without food or water. With the use of the family traps crowding during the warmer periods of summer may be an adverse factor. Details in setting the traps were aimed at eliminating or alleviating the effects of such conditions.

Traps were ordinarily set in the afternoon, and, during hot weather, reasonable efforts were made to remove the catch by an hour or two before noon of the following day. During the warmer months, a compact bundle of fine vegetation, dipped into the water to hold added moisture, was placed in the holding compartment. This furnished food and more particularly moisture for the captives. An excessive amount of vegetation was not desirable because the animals were prone to scatter it about and foul the free action of the upper entrance gate. During cooler weather, moisture is apparently not so important, but handful of dry grass or rushes will be readily utilized by the animals in forming a nest. Lastly, the provision of two or three ample handfuls of vegetation on top of the trap added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much needed insulation. Emergents, willow branches, or vegetation of a type most easily procured at the trapping site, were pushed under the long wire handle on top of the trap. The handle thus served as a batten for holding it in place. Submerging the vegetation before placing it on the trap helped to maintain cooler temperatures. In addition to insulation, the vegetation helped to camouflage the traps, possibly allaying suspicion by the muskrats somewhat as well as rendering the devices less conspicuous to passers-by.

TRAPPING SUCCESS

During the late summer and early fall of 1946, intermittent use of up to five family traps, much of it experimental while developing the traps, resulted in 186 muskrat captures. In 1947, muskrats were taken by hand as nestlings, in "National" live traps (a commercial wire box trap of more or less conventional design—see Aldous, 1946) and in family traps during April through November to give a total of 903 captures. The total included muskrats that were recaptured and a few that were untagged. The family traps were mainly used from July through October, with use during earlier and later months being limited or intermittent largely as a consequence of weather and river conditions. The 1947 catch in family traps was 641 including recaptures, which added to the 1946 figure gives a total of 827 captures by this means during both years.

National live traps were for the most part used in a limited number of situations where the family traps were not well adapted, as an aid in capturing post nestlings, or for other special purposes. In general, the family traps were regarded as being more efficient and better adapted to the investigation. A distinct advantage of the family traps was to be had in the distance between the basal part and the holding compartment which allowed considerable leeway for the accomodation of water fluctuations or wave action. This feature not only provided for the safety of the catch, but also obviated much of the caution required with the use of the National traps which were set at or near the water surface for best effectiveness. Similarly, the relatively large holding compartments of the family traps made it possible to more adequately provide for the welfare of captives. The inclusion of vegetation within National

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Plate 1.

A—Side view of trap, cover to holding compartment removed;
B—End of basal tube showing main entrance gate;
C—Details of entrance to holding compartment. Gate sill is stepped; side plates prevent gate from dragging against the wire meshes;
D—Trap set in runway at den entrance;
E—Handling cage, darkening cloth removed. Point *a*, drop board in place. Point *b*, wire skewer holding lid in elevated position. Point *c*, insertion places for skewer when lid is lowered;
F—Handling cage, captive pinned down for tagging;
G—Method for weighing muskrats (see Fig. 1);
H—Method for measuring muskrats. Specimen has foreparts slightly hunched.

traps seemed desirable and was undertaken, but there was little room for such without impairing the action of the trigger mechanism.

Analysis of 1947 trapping records from July 7, through September 13, during which time the writer had the services of an assistant, reveals that 476 muskrats were taken in family traps during 44 nights, an average of 10.8 per night. During this main trapping period, from six to ten family traps placed at from two to five den sites constituted the approximate daily schedule. The nature of the habitat and the breeding populations were such that very often a considerable portion of the day was spent in laboriously searching for "signs" of muskrat activity and den locations. Since plans called for a rather intense coverage of the trapping area, the number of muskrats caught was probably well below what might have been taken had the trapping been done in a more selective way, favoring easily located or readily accessible den sites.

The catch at a den site typically consisted of representatives from a single family group; besides one or both adults, it very commonly included members from two successive litters. Under optimum conditions, it was possible to take what appeared to be (on the basis of subsequent trapping) an entire family group in one operation with an appropriate complement of family traps. More commonly, two or more trappings separated by intervals of a week or so were necesary to capture what was considered to be all or nearly all of a particular group. Juveniles weighing less than approximately eight ounces were not ordinarily taken with consistency, although there are numerous records of captives below this weight. Loose family relationships involving especially the older subadults, the size of young as related to their habits of movement to and from the nest chamber, and conditions discussed under "Limitations and Causes of Trapping Failures" were among the determinants of success.

Although burrows were trapped in a manner so as to avoid as far as practicable the likelihood of crowding within a single trap, several catches of from seven to nine muskrats occurred during each of the summer months. In one extreme case during July, and which is without parallel during the trapping period reported upon, eighteen muskrats of various sizes were taken within a single trap in one operation. The group consisted of survivors of several litters (weights ranged from five to fifteen ounces) plus an adult male and two adult females. In another runway connected with the same burrow system, an additional trap captured two more juveniles. One of the adult females was lactating freely, and had been previously tagged along with four of the young. The other adult female was pregnant and gave birth to one offspring while the operators were handling the catch. The incident was even more surprising to the operators, since the catch was made in a shallow runway that gave little evidence of heavy use at the time when the trap was set. Unfortunately, as a result of unexpected delays, the trap was not visited until well after the heat of the day had commenced. This factor in combination with that of the animals being literally packed one on top of another led directly or indirectly to the death of four of them. From one to five animals per successful trap was the usual catch

with the trapping methods employed.

Mortality in the family traps during July included only one individual in addition to the previously mentioned four, which amounted to 2.8 per cent of all captures by this means for the month. During the same period, an equal number of animals were killed in National traps, despite precautions for shading, etc. Out of a total of only 22 captures there was a 22.7 per cent mortality. For this reason, use of the National traps was largely discontinued during the warmer periods of summer. Aldous (1946) reported much lower losses with the use of National traps in South Dakota, and inspection of his data (p. 44) suggests that losses were proportional to the number of times animals were recaptured, "... 251 entered the traps once; 80 returned for a second capture (of which 8 died in the traps); 24 returned for a third capture (4 died); eight returned for a fourth time; and four returned for a fifth capture (3 died)." In Iowa the National traps were often selectively used favoring the capture of post nestlings, probably the most vulnerable age class with regard to stress from trapping. Four of the five National trap victims were from five to ten ounces in weight. There was also some evidence, though inconclusive, to indicate that a disease acting against the young may have been a contributing factor in the death of at least some of the smaller victims (true also in the case of two small young that died in the family traps). A certain amount of skin disease and other signs of unthriftiness was present among the smaller young which gave evidence of many symptoms in common with those described by Errington (1942) in young muskrats of central and northwestern Iowa as of serious if not mostly fatal consequence. Errington attributed the disease chiefly to a fungus which was identified by V. K. Charles, Bureau of Plant Industry, U. S. Department of Agriculture as *Trichophyton mentagrophytes* (Robin) Blanchard.

Limitations and Causes of Trapping Failures

It is probable that the family live traps were somewhat less efficient than were the old under water box traps. The latter were smaller and less conspicuous in the runway and animals that did not escape within a few minutes after entering were drowned. With the family live traps, captives may have hours to tug and root at the gates. An undetermined but small number of those entering were thus known to make their escape.

Trapping success at certain types of vegetative lodges, present in the spring and fall, was sometimes poor or not markedly better than could be expected with smaller live traps of more conventional design. A common difficulty lay in not being able to readily locate the main or important openings leading to such structures. The runways connected with the openings were sometimes too short or too shallow for the best use of the traps. In the cases of some of the numerous houses which were constructed on tree stumps, the openings were among the roots with no distinguishable travel lanes. Even so, adequate trenched runways could be located at a majority of houses that had been in use for several weeks and the traps employed with success.

Occasionally, operation of the traps was impaired by a heavy deposition of silt which clogged the lower gates. This

seemed to result from the customary digging activities within a burrow system, digging activities presumably stimulated by the presence of the trap, or what were regarded to be direct attempts of the animals to fill or bury the trap. Retrapping a week or so later generally met with success.

During late summer and early fall, a frequent cause of difficulty arose as a result of the multiplicity of runways within an established family territory. The currently active routes in a series of runways could not always be determined. And indeed, a loose family relationship plus localized shifting around, especially of older sub-adults, might require that all runways be trapped. The opportunities for gaining insight into such relationships, nevertheless, were enhanced. It was sometimes possible to secure data of a type that might not have been obtainable with other trapping methods.

In many cases, including some of the foregoing, trapping failures or poor success might logically have been attributed to difficulties associated with the habitat trapped. On the Mississippi River, the rather drastic extremes in water levels in response to seasonal variations in rainfall are well known and may be regarded as of "normal" occurrence. In addition, frequent small fluctuations took place, largely as a consequence of water level manipulations at a series of navigational and flood control dams. One effect upon muskrats, whether the fluctuations are caused by manipulations or otherwise, is to force shifts in their living quarters. These range from temporary flood shelters, which usually approach in form the more conventional vegetation lodges with continued occupancy, to bank burrows with chambers and openings at various levels. There were substantial periods during which the entire trapping area was inundated by two or three feet of water. At the other extreme, a considerable part of the area was accessible for much of the trapping period only by laboriously poling a boat through a few inches of water. On one occasion during the summer of 1947, the waters receded so abruptly that many den openings and runways still in active use were exposed on the mud flats, or contained but an inch or two of water. Changes were usually less severe and somewhat predictable. The muskrats responded by digging new burrow entrances, deepening runways, relocating nest chambers, building, abandoning, and reoccupying old dwellings. It is apparent that such a degree of instability was conducive to trapping inconsistencies.

HANDLING CAGE

First attempts at removal of muskrats from traps and restriction of their movements sufficient to permit eartagging were met with some difficulties. A chickenwire netting cone with a wedge-shaped wooden base (Aldous, 1946) was first employed. Difficulty was encountered in handling different sized muskrats, and most were hard to extract from the cone for further handling or release. When we attempted to pull the larger animals from the cone by means of a grip on their tails, they usually braced their feet against the meshes and could not be budged without undue roughness. The problem of handling different age-classes of animals, without employing several cones or additional accessory paraphernalia, presented an obstacle. A similar cone

was developed with the netting secured to a quarter-inch iron rod at one side, which was in turn held to the wooden base by two hooked wire catches, permitted the cone to be opened up along the entire length for easy removal of captives. However, the problem of handling the different sized animals was still not solved. The operator at the time was working alone and tagging was still an awkward procedure requiring the use of one knee for holding the baffle in place in order to free the hands for the act of tagging. Erickson (1947), working with small mammals ranging in size from cotton rats to house mice, experienced similar difficulties with a cone shaped holder. He modified the same by incorporating removable transverse baffles at intervals along its length.

Plate 1, E illustrates a handling cage devised in this investigation in the summer of 1946 which remedied most of the difficulties previously encountered. The device admittedly has a few objectionable features, namely that discretion must be exercised in subduing the struggles of advanced pregnant females. However, it has served rather well in actual practice, functioning as a handy catching and carrying cage as well as a restraining contrivance. The open end of the cage can be inserted a few inches into the catch removal doorway of the trap or into either end at the base for removal of captives. It was usually employed at the upper opening, and so placed, with drop board elevated and the whole darkened by draping with a cloth, muskrats could usually be readily induced to enter. To accomplish this, the operator thumped or agitated the trap and blew his breath inside the top compartment. In placing the cloth, a small "peek hole" was left near the drop board, and the latter was quickly lowered after an individual had entered the handling cage. Sometimes muskrats displayed exasperating obstinacy in refusing to leave the sheltered top enclosure in the usual manner. If so, the entrance gate to the holding compartment was pried open by working a twig through the wire meshes, and the offender could usually be driven to the bottom of the trap and into the handling cage previously inserted at one end. When placed at the lower position, the handling cage automatically elevated the entrance gate. After considerable experience in handling live muskrats has been acquired, the animals can usually be removed from a trap rather quickly by simply taking a firm grip on their tails and dragging them forth. This procedure requires slow and cautious manipulation of the gloved hand, until the tail is grasped after which the animal must be withdrawn briskly. When suspended by the tail, they readily sought the shelter offered by the darkened enclosure of the handling cage. Within the latter they usually remained relatively quiet if kept covvered by the cloth.

For tagging operations, a secure hold was taken on the cage lid handle, skewers removed, the animal forced down against the bottom of the cage, and locking skewers reinserted in the appropriate lower position (Pl. 1, F). Only enough pressure was brought to bear to restrict movements generally, without attempting to sufficiently "mash" the captive to the extent of preventing lateral movements of the head and legs. With the animal thus held, the operator had both hands free for tagging. And after placing a leather

glove or folded cloth over the muskrat's foreparts, slight additional pressure in this region with base of the left hand, while the thumb and fore fingers held the ear to be tagged, was sufficient to hold the head still enough for the tagging operation. The convex design of the lid offered a safeguard against oversqueezing the smaller animals. Likewise, the series of insertion places for the skewers (Pl. 1, E point *c*) provided considerable latitude for making adjustments for the various age-classes.

If desired, the genitalia, mammae, etc. can be inspected or exoparasites collected while the animal is thus pinned down. However, after experience was gained in handling live muskrats, it was usually found preferable to make inspections by holding the animal suspended by the tail with forefeet resting upon some firm object, as recommended by Dozier (1942). Animals were also handled by the tail during weighing and measuring procedures.

For weighing (Pl. 1, G), the ends of a short shoe lace or piece of soft cord were tied together, and a lark's head knot (Fig. 1) was made in the loop opposite the joining knot. The scaly portion of the tail was slipped through the loops of the lark's head knot, the latter drawn up snugly near the base of the tail, and the animal suspended from the hook of a small spring instrument scales (five pound capacity). In dealing with some animals that kicked persistently, firm pressure applied to the end of the tail with thumb and fore finger usually caused them to desist long enough to permit a reading to be made immediately after the tail was released. An obvious advantage of this simple procedure for weighing was to be had in the small size and weight of the necessary equipment, which could be conveniently stowed away in a coat pocket.

Measuring the total length and length of tail (scaly portion only) was accomplished by holding the muskrat suspended by the tip of the tail against a measuring stick (Pl. 1, H). At the bottom of the stick an additional three-inch piece projected at right angles from the calibrated side after the fashion commonly seen on measuring boards for biological specimens. Accurate total length measurements were difficult to obtain because of the tendency of muskrats to humch themselves while hanging by their tails. By reading the rule at opportune moments, however, and by allowing the animal barely to grasp the horizontal end piece with its fore claws, reasonably accurate and consistent readings could be obtained.

TAGS AND TAGGING

Small fish fingerling tags of a type previously used with success in the ears of wild mice (Scott, 1942) and in the ears of muskrats (Aldous, 1946) gave satisfactory results. The writer ordinarily placed the tags in the anterior margin of the pinna with point of puncture near the skull. Two commercial types of tags, closely resembling each other, were used: (1) Size 1, Style 1005 of the National Band and Tag Company and (2) a similar tag, "Fingerling Size," of the Salt Lake Stamp Company. Both were subject to refinements as a result of experience gained in their use. Tags of type (1) were considered superior for the purpose and were mostly relied upon. However, a supply of such tags received in the spring of 1947 had very sharp edges on the inner side, which

seemingly delayed healing by continued laceration of the ear tissues at the point of insertion. After removing this edge by scraping it once or twice with the small blade of a pen knife, or by the use of a small file, the tag was used with good results.

Tags of type (2) were of much thinner metal, and whereas there were no cutting edges, the shape of the tag had objectionable features. When pinched shut by an applicator, the enclosed space was much too narrow, and especially so in the region of the tongue of the tag which passed through the ear. A few trials were met with poor success, manifest by severe swelling, abscess formation, and probable eventual sloughing away of tissues enclosed by the tag. In order for a tagging wound to heal without complications, it was important that enough space be present between the tag and the enclosed portion of the ear to allow for a reasonable amount of normal swelling. Otherwise, the pinching of the tag against the inflamed tissues seemingly hampered circulation. After tags of the second kind were rebent to allow a longer tongue and clearance after clinching of about 2.5 mm., they were inserted with an applicator intended for tags of kind (1) (this applicator had a wider gap for holding the tag) with very little trouble. Rebent tags of this type were used by preference on some rather small nestling muskrats in consideration of the light weight of the tag and the small size of the ear. One such nestling, tagged in May, 1947, when but $6\frac{5}{8}$ inches in length and weighing approximately two ounces, was recaught by a fur trapper the following December with tag intact.

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BRIEFER ARTICLES

LARGEMOUTH BASS FOLLOWING SWIMMING ANIMALS

Mr. W. C. Vogt (*vide* Seton, E. T. Lives of Game Animals, p. 497, 1928) described an interesting association between beaver and trout (Field and Stream, March 1921, p. 1004). He observed six large trout lying directly under the belly of a large beaver. They apparently paid little attention to the beaver until it slapped the water with its tail at which the trout would dash for cover. Seton stated, "They seem to recognize the beaver as friend and protector."

It is common knowledge among largemouth bass fishermen that these animals often lie under logs and rocks either for protection or in wait for prey. It does not seem to be generally known that largemouth bass (*Micropterus salmoides*) will also follow swimming animals or floating objects.

Several years ago on an artificial pond near Auburn, Alabama the writer observed a pair of mallards (*Anas platyrhynchos*) swimming across its surface. A largemouth bass, estimated to weigh over four pounds, was swimming slowly about a foot below and a few feet behind one of the ducks. As they reached shallow water they began tipping up and feeding along the opposite edge. The bass continued to follow slightly below and to one side of the feeding birds. As the ducks moved away the bass was lost to sight but a few minutes later a large one struck viciously at something on the water's edge near the feeding birds. On several different occasions large bass were seen to strike in shallow water near these ducks. Their prey could not be observed but it was believed to have been the frogs and small fish being frightened from the vegetation by the feeding birds.

During a beaver trapping and transplanting program in Alabama a largemouth bass was caught in a Bailey live trap with a 42 pound beaver (*Castor canadensis carolinensis*). The bass, estimated to weigh three pounds, was slashed in numerous places by the beaver's incisors and was dead when discovered by the trapper. The beaver made no attempt to eat the fish. In order to have been taken with the beaver, the bass must have been swimming within a foot of it when the trap was sprung. On another occasion a two pound bass was taken at the same time a large swamp rabbit (*Sylvilagus aquaticus aquaticus*) was caught in the Bailey live trap set in a beaver pond. The bass was unharmed by the rabbit. It must have also been swimming very close to the rabbit when the trap was tripped.

From these observations it appears that the largemouth bass will follow several species of swimming animals. We present the hypothesis that the bass feed on the prey flushed from hiding by the larger animals.

Mr. Vogt's trout observations lead me to believe that they also might have discovered the swimming activity of the beaver to be an aid in obtaining food.—FREDERICK S. BARKALOW, JR., *Professor of Zoology, N. C. State College of Agriculture and Engineering, Raleigh, N. C.*

SOME VEGETABLE FOOD ITEMS TAKEN BY RAINBOW TROUT

While the writer was examining the contents of some trout stomachs taken from streams in western North Carolina, an unusual item appeared in a 14" rainbow (*Salmo gairdnerii irideus*). This specimen was taken on August 30, 1948 by a fly fisherman at the head of Wilson's Creek in Avery County. The stomach contained seven fully mature watermelon (*Citrullus vulgaris*) seeds. Several others were found in its throat. The stomach contained no other items. The trout, which appeared to be in excellent physical condition, was caught from a pool a few yards below the Scenic Highway. It was apparently feeding on the seeds as they floated down stream from a nearby picnic site.

Rainbow trout are reported by the natives to be fond of the fruit of the service berry (*Amelanchier sp.*) but no trout stomachs taken during this fruit's period of availa-

bility have been examined. Trout in several protected areas in North Carolina eat bread readily but the above instance is the only one of which I am aware that indicates they feed on watermelon seeds.—FREDERICK S. BARKALOW, JR., *Professor of Zoology. N. C. State College of Agriculture and Engineering, Raleigh, N. C.*

OBSERVATIONS OF COLOR-DYED PHEASANTS[1]

During the spring of 1948, observations were obtained on color-dyed pheasants to determine dispersion and mortality of released birds. Wadkins (1948, Journ. Wildl. Mgt., 12(4): 388–391) tested various dyes for color marking pheasants and concluded that some "... dyes are a practical, inexpensive, and quick method of marking pheasants for field study." The dyeing technique used in this experiment is based on work done by Wadkins.

Some reaction behaviors between the colored pheasants and wild resident birds were obtained incidentally to the primary objectives.

Nineteen pheasants were dyed and released on the study tract. Eleven were dyed with the alcohol-water solution, and eight were dyed in one per cent acetic acid according to the recommendations of DuPont and other dye companies. Eight birds were kept as controls in the holding pens and represented all colors of the released birds except green and brown. Auramine concentrate (a yellow dye) was used on two of the experimental pheasants. Combinations of dyes were used on the others that produced brown (Auramine, Rhodamine B-extra, Malachite Green), purple (Rhodamine B-extra, Malachite Green), and salmon (Auramine, Rhodamine B-extra) colors. Where combinations of dyes were used, the least permanent dye faded leaving the more permanent dye with its characteristic color. In all cases the dyes retained their greatest brilliance under the wings and on those feathers protected from the weather. Identification of sex in the field was not affected since none of the dyes camouflaged the darker plumage of the cocks. A large pan with a quarter inch of dye solution (one pint per two birds) was used for dyeing the pheasants. They were rolled gently in the pan so that the wing and tail feathers were well saturated. The body feathers, however, matted, and the dye did not penetrate to the skin. After treatment the birds were held in cartons overnight to dry. By morning the feathers dried, and they had regained their natural fluffiness.

The area used in the study consists of approximately one square mile of diversified habitat one quarter mile northeast of the town of Pullman, Washington. Most of the pheasants were released on a small hill covered with locust trees (*Robinia* sp.). A short ridge extends westward from the hill. The slopes of the ridge had been used for raising wheat and for garden plots which still contained standing corn stalks, squash, cabbage and melons at the time of release. The gardens were overgrown with nightshade (*Solanum*), amaranth (*Amaranthus*), sweet clover (*Melilotus alba*), and other weeds. Bordering the gardens to the west and south were small pastures, a few residences and two roads. Further to the west were scattered clumps of *Symphoricarpos*, *Crataegus* and *Amelanchier*. On the east the gardens are bordered by an apple orchard, golf course and college grass plots, whereas the north is bordered by extensive plowed fields. All in all the area contained excellent-appearing cover, roosting sites and natural food.

Approximately twelve wild pheasants and four Hungarian partridges occupied or used the area at the time the study was initiated.

Regular observations were made at or near the release site, and occasionally the adjacent pheasant range was checked, usually without seeing dyed pheasants. Table 1

[1] Acknowledgement is made to the State Game Department for contributing the pheasants used in this experiment, to the DuPont de Nemours Company for the dye samples, to Dr. Julia Southard Lee of the State College of Washington and Dr. Louis Olney of the Lowell Institute in Massachusetts, who assisted in finding out what dyes to use and how to use them, and to Dr. Irven O. Buss for help in preparing the manuscript.

TABLE 1.—OBSERVATION RECORD

Color	Release Date	Dates Observed: February	March	April	May	June	Remarks
GREEN							
2 hens	2/7/48	8(1)–11–12–19–26	11		22		(1) One hen seen feeding with eight wild hens.
2 cocks	2/7/48	8–11–17–18(2)–21	11–12–13–14	14–15–18–19			(2) Dead, brought in by dog to a farm three miles from point of release.
RED							
2 hens	2/7/48	8–11–12–16–18–21–22	6–11		2(3)		(3) Seen with wild hens and cock. Flushed, color very distinct.
5 cocks	2/7/48	8–10–11–12–	6–7–9–11–	3(4)–13–			(4) Found dead half mile from point
	2/14/48	19–20–26	12–13–14–19–29	14–15–18		3	of release. One killed by poacher. Two others found dead.
PURPLE							
3 hens	3/16/48		21	4(5)–18(6)			(5) Found dead 2 miles from point of release.
							(6) One killed by dog. One brought in dead by dog.
1 cock	3/16/48		21(7)				(7) Killed and eaten, probably by hawk or owl.
YELLOW							
1 hen	3/19/48				16–18–19		Very conspicuous color.
SALMON							
1 hen	3/19/48				10(8)		(8) Reported at St. John which is about 30 miles from point of release "air line."
BROWN							
1 hen	3/19/48		27	11–12–13–15–16–18–19–23–28			
1 cock	3/19/48						Never seen after release.

summarizes these observations. The eight pheasants released February 7 were seen the next day within a quarter mile of the release site. One of them, a hen dyed green, was feeding with seven wild hens. Six were resting under a brush pile, and one cock was off feeding by himself. Tracking the birds at this time was simplified because dye marks were left in the snow where the birds rested. The bright colors contrasted sharply with the white background.

Observations of these birds and of later releases revealed no unusual behavior. The dyed pheasants mixed freely with wild pheasants and various combinations of dyed and undyed pheasants were seen frequently.

Two months from the time of release (mid-April) eight pheasants had died or had been killed, one was not seen, and the nine remaining birds were living on the area when observations terminated on June 25. As the weather moderated, movements were extended and fewer birds were seen near the release site. However, a hen dyed green and a cock dyed red were reported four months after liberation near the release site.

Some differences were noted in the dye's resistance to fading. The Malachite Green faded much sooner than either the Rhodamine B-extra or the Auramine. Two months after being dyed green, cock pheasants could not be distinguished from the wild pheasants unless they were flushed; whereas, the cocks dyed red with the Rhodamine B-extra could be positively identified three months after being dyed without flushing them. This red dye was the most satisfactory on the cocks.

The dyes used on the hen pheasants were all easy to see. The most satisfactory color depended on the type of habitat in which the bird was released.

Under favorable light conditions and without the aid of binoculars these pheasants were identified accurately from over a quarter of a mile.

The experiment showed that this technique can be used effectively to study the dispersion, behavior and mortality of released pheasants. It also corroborated Wadkins' findings that pheasants properly dyed will remain visibly colored for two months or longer when not flying and for four to six months when flushed. No differences in behavior were observed between dyed and wild pheasants.—GARDINER F. JONES.

A METHOD FOR FILING FIELD OBSERVATIONS

The field notebook can be a hard taskmaster as well as an invaluable tool to the wildlife manager. Summarizing and tabulating data from hundreds of observations often require more time than the field man is able to spend in office work, although he knows that the most carefully recorded observations have only potential value while they remain in the notebook on the shelf. The more complete and detailed the field records, the more difficult they are to integrate into usable form. At times, even the most conscientious observer is tempted to pass over an important but complicated observation because he has no immediate use for the data. The field notes made on the Huntington Wildlife Forest Station, Newcomb, N. Y., are being handled by a method which puts all the data in a form where they are ready for immediate use and at the same time their evaluation involves a minimum of office work.

The data from all observations which are simple records of animal distribution or from routine observations on special projects are transferred directly to tables or maps. These data then provide a cumulative record of progress and indicate species and areas which need special attention. Observations on rare species, unusual phenomena, or complicated records of animal behavior or habitats which cannot be completely and immediately transferred to a table or map are copied on observation record forms (purchased from the Moore Business Forms, Inc., Niagara Falls, N. Y.) and filed by subject matter until enough similar observations are made to justify tabulation. These forms are constructed in continuous style, on three superimposed sheets of card-stock paper, interleaved with "one-time" carbon. The forms are 6 inches wide, perforated every 4 inches, so that each observation is filed on a 4 by 6 inch card. The continuous construction allows constant typing without inserting and removing a form for each observation, and results in a great saving in time for the typist.

The forms are made to individual order, and the size of the card, number of copies, color of paper, and printed material can be altered to suit the specific methods used by any worker. The cost of the forms now in use is approximately 1.2 cents each. In comparison with single cards and loose carbon paper, and considering the saving of the typist's time, we have found the costs to be quite comparable.

The field man makes his observations readable and understandable, and indicates, at the beginning of each observation, all subject headings under which the record is to be filed. The typist copies the observation on a separate form for each of the subject headings, and on each, indicates all the cross references. The original copy of each observation is filed by subject in the Syracuse office; the first carbon copy is used as a chronological record of activity and is filed by date and observer; and the second carbon copy is filed by subject heading in the field office on the Huntington Forest.

An example may clarify some of the values of the method. A field man who observes the behavior of a red fox in the vicinity of a deer fawn makes a detailed record of the observation and indicates that it should be filed under both red fox and fawn. The typist duplicates the observation on two forms, one of which is filed under red fox and the other under fawn. After several seasons of work there may be several similar observations and it is a simple matter to summarize and tabulate the data, which are already assembled. In the case of rare species, the method has proved particularly valuable. In ten years of field work there have been 16 observations made on fisher on the Huntington Forest. The number of records on this species increases slowly but the information is always up to date and ready for use. The availability of all data recorded has proved to be a real stimulus to the field men, as they know that all observations made will be put into usable form, not buried in the field notes.—WILLIAM L. WEBB, *Roosevelt Wildlife Experiment Station, The New York State College of Forestry, Syracuse, N. Y.*

REDUCTION OF MORTALITY IN LIVE-TRAPPING MICE

Live-trapping has proven to be a technique of considerable merit in life history and population studies of small mammals. The method has certain shortcomings, however; one of the most serious of these being the death of individuals during their confinement in traps. "Trap weakness" and "trap-deaths" presumably are a result of exposure, and some individuals expire the first time they are trapped. It has been noted on numerous occasions, however, that "repeating" animals may become progressively weaker at each capture, indicating that the debilitating effects of trap confinement may be cumulative. This result of trapping is of particular importance where long-time recognition and recapture of given individuals is a prime objective.

Investigators have tried to minimize such trapping mortalities by including nesting materials which would insulate trapped animals against extremes of temperature and humidity. Aside from being only a partial remedy to the problem, the inclusion of protective materials in traps has several objectionable features: It complicates the removal of animals from the traps; it often becomes enmeshed in the trap mechanism thereby necessitating cleaning and readjustment of the traps; and even non-absorbent materials become wet and packed and require frequent replacement.

At the Patuxent Research Refuge, Laurel, Maryland, a modification of the Evan's vermin trap has been used for studies involving the live-trapping of fur mammals. It was noted that mice trapped in these hardware cloth traps suffered only a very negligible mortality even though the large trap offered less shelter than small mammal traps of usual design. It appeared likely that the low mouse mortality in these large traps was due to better opportunities for keeping warm through exercise, and/or better ventilation which would allow for faster drying of the trapped animals. It was noted, also, that trapped mice ate freely of ear corn used for bait in the large traps, and it was theorized further that the energy producing qualities of corn may have contributed to the high survival of mice in these traps.

In order to test this theory a few Sherman metal traps, size 3×3×10 inches, were baited with a handful of shelled corn. No bedding was used and the catch was removed once a day, but not necessarily in the morning. These traps were run sporadically for about two weeks, with most of the catch being woodland deermice (*Peromyscus leucopus noveboracensis*). It was found that all of the mice survived and were in good condition, even when the temperature neared the freezing point. A further check was made by setting a line of 50 Sherman traps, half of which were baited with peanut butter and the other half with a small amount of peanut butter plus a handful of shelled corn. These 50 traps were run from April 4–12, 1948, and the results are given in Table 1.

A third test was run from April 13–21. Two lines of 25 traps each were set. The traps of one line were baited with 15 grams of shelled corn alone and the others with a quarter teaspoonful of peanut butter plus 12 grams of rolled oats. This made the weight of the baits used in the two lines about equivalent, but the quantity of oats and peanut butter was much larger than is normally used. No bedding was used, all animals were tagged and the traps were visited once a day. Because of the low catch this experiment was not conclusive, but the results obtained are in agreement with those obtained in other tests. Five different mice were taken in the line of traps baited with oats and peanut butter. Of these, one was dead after repeating four times, another showed signs of trap weakness on its second appearance, and a third chewed its feet when caught the third time. All mice caught in the corn-baited traps were well and lively when released. After numerous repeats the corn-fed mice nearly always seemed more vigorous than the mice having access only to oats and peanut butter. The catch in each line was about equal. During the trapping season of 1948 Lucille F. Stickel made a practice of setting all traps without bedding and putting 1 to 2 tablespoonfuls of corn in each trap in addition to a small amount of rolled oats and a trace of peanut butter. The results of three periods of trapping are given in Table 2.

The data in Table 2 indicate that although the 1948 trapping was carried on over a longer period, with many mice repeating a greater number of times, mortality was greatly reduced and trap weakness eliminated. It should be noted that in two short periods in 1946 the mortality based on the number of captures was 10 and 28 times as great as in the longer 1948 period.

Briefly the advantages of using corn for bait or as a bait supplement seem to be: (1) Mortality and trap weakness are much reduced; (2) Considerable time is saved in providing and adding bedding materials for traps and in subsequent cleaning of traps which nesting materials necessitate; (3) It is easier to remove animals from traps; (4) Baiting is simplified if corn alone is used; (5) A bait of rolled oats becomes damp, soggy and unattractive very quickly, whereas corn remains edible much longer.—LEONARD M. LLEWELLYN, *Fish and Wildlife Service, U. S. Department of the Interior, Patuxent Research Refuge, Laurel, Maryland.*

TABLE 1.—EFFECT OF BAIT ON *Peromyscus* TRAPPED APRIL 4–12, 1948

Bait	No. Mice Collected	No. in Normal Health	No. Weak	No. Dead
Peanut Butter	29	15	5	9
Peanut Butter+Corn	21	21	0	0

TABLE 2.—TWO TRAPPING PERIODS WHERE BEDDING WAS USED WITHOUT CORN COMPARED TO THIRD IN WHICH CORN WAS USED WITHOUT BEDDING IN TRAPPING *Peromyscus*

Dates	Bait	Bedding	No. of Mice	No. of Captures	No. Weak	No. Weak per 100 Captures	No. Dead	No. Dead per 100 Captures
Aug. 9–19, 1946	½–1 Tbsp. rolled oats +½–½ Tbsp. peanut butter	cotton	115	398	6	1.51	6	1.51
Aug. 27–29, 1946	Same	cotton	132	252	11	4.38	10	3.97
Aug. 11–Sept. 26, 1946	½–1 Tbsp. oats+ trace peanut butter +1–2 Tbsp. corn	None	96	1425	0	0	2	0.14

MINNOW SEINE SAMPLING

The review of *Fish Ponds for the Farm* by Frank C. Edminster, written by George Bennett (Journ. Wild. Mgt., 12(2): 215–217. Apr. 1948), contains a criticism of the minnow seine method of sampling farm ponds for the determination of "balance." The reviewer intimates that the method gives little information on populations—and, hence nothing on balance. While the intimation is correct, the minnow seine method of sampling is *not* used for the determination of numbers. It is instead taken as an indication of weight ratios between predaceous fish and their prey. Unfortunately, Mr. Edminster's book does not deal with that relationship under the section "Maintaining the Fishing" (Chap. 8, pp. 105–107). Size classes are an important element of the minnow seine sampling method, but only as they reflect a food condition which in turn influences weight ratios.

"Balance," as shown by the minnow seine

method of sampling, means that for each pound of bass in Edminster's ponds there are from 2 to 7 pounds of bluegills. In this case it shows that both species are actively growing and uncrowded. This sampling method indicates immediately that food resources in a balanced pond have been ample to provide for the continuous reproduction of bluegills during the appropriate season, as well as for the more limited reproduction of bass. In the unbalanced pond the sample points out the direction of weight distortion.

Based upon H. S. Swingle's careful research,[1,2] upon these two species of fish, the minnow seine method of sampling has been used with a high degree of success in the evaluation of hundreds of farm ponds—well over 300 in my personal experience.

Bennett's comment that "little information on . . . the kind of fishing that the pond will produce may be gained by seining up their (bass and bluegill) young along the pond edges" is erroneous in part and somewhat misleading. The kind of fishing in a pond is dependent to a considerable extent upon total productivity. It is somewhat reflected in the skill and persistence of the fishermen. Because a relatively large proportion of the poundage of fish in ponds showing "balance" by the method in question are of "keeping-size," the fishing usually is good. Conversely "unbalance" indicates a crowded population of bluegills, a condition which results in very poor fishing. But since a pond which produces only 25 pounds of fish per acre may be in as good a weight balance as one which produces 250 the actual catch may vary widely.

No simple, yet practical system of analyzing farm ponds on the basis of numbers has been devised. To date the minnow seine method has proved the most useful technique in analyzing farm ponds on a large scale, and its accuracy has not yet been seriously challenged.—PHILIP F. ALLAN, *Chief, Regional Biology Division, Soil Conservation Service, Fort Worth 1, Texas*

[1] Improvement of Fishing in Old Ponds. H. S. Swingle. Trans. N. A. Wildlife Conf., 10: 299–308 (pp. 301–302).

[2] Experiments on the Stocking of Fish Ponds. H. S. Swingle and E. V. Smith. Trans. N. A. Wildlife Conf., 5: 267–276 (pp. 274–275).

To which Dr. Bennett replies:

The statement to which Mr. Allan takes exception is as follows: "Experience with the minnow seine method of sampling ponds to test their 'balance,' in a number of cases where the larger fishes were being intensively studied by other methods, indicates that little information on the adult bass-bluegill population or the kind of fishing that the pond will produce may be gained by seining up their young along the pond edges."

In the first two paragraphs of Mr. Allan's statement he credits assumptions to the original authors of the minnow seine method that are not to be found in their publications: . . . "The minnow seine method of sampling is not used for the determination of numbers. It is instead taken as an indication of weight ratios between predaceous fish and their prey. . . . 'Balance,' as shown by the minnow seine method of sampling, means that for each pound of bass in Edminster's ponds there are from 2 to 7 pounds of bluegills." I can find no such statement made in the Swingle and Smith publications listed as a footnote in Allan's paper, nor can I find such a statement in Edminster's book or in Wallace L. Anderson's paper.[1] From what source, then, has Mr. Allan gathered this information?

My own objection to the minnow seine method is illustrated by the Fork Lake experiment (Bennett, Geo. W., 1948. The Bass-Bluegill Combination in a Small Artificial Lake. Ill. Nat. Hist. Surv. Bull. 24(3): 377–412. Dec.). Each year after the bass stocked in Fork Lake had become sexually mature, we observed a large spawn of bass and bluegills (1940, 1941 and 1942) and young of both species could be captured easily with a minnow seine throughout the summer (except after the dam washed out in 1942). Yet during this same period the annual yield varied: 1940—200.2 pounds; 1941—129.9 pounds, and 1942—60.5 pounds

[1] Anderson, Wallace L. 1948. Results of an Analysis of Farm Ponds in the Midwest. Prog. Fish Cult., 10(3): 111–16, July.

(April, May and June). At the same time the intensity of the fishing was being increased each year. The average catch per man-hour of fishing (hook-and-line) was as follows: 1940—3.2 fish per man-hour; 1941—2.9 fish; 1942 (April, May, June)—0.0. In 1940 the bluegills averaged about 0.30 pound each; in 1941 they averaged about 0.18 pound; in 1942 they averaged not more than 0.10 pound. The bass averaged about 0.40 pound in 1940, 0.75 pound in 1941 and 1.50 pounds in 1942. Throughout this period the pond contained what must be considered a dominant population of bass. Yet the minnow seine method indicated that the pond was in "balance."

Incidentally, the young bass that were used to stock Fork Lake in 1938, at the beginning of that study, were collected with a minnow seine from Homewood Lake (2.83 acres) where all fish were badly stunted. The lake contained 699 pounds of fish per acre; bass made up 2.3 per cent of the total weight of all fish. The fish population consisted of largemouth bass, white crappies, black crappies, bluegills, warmouth bass, green sunfish, pumpkinseed sunfish, orange-spotted sunfish, yellow perch, yellow bass, black bullhead, yellow bullhead, carp, redmouth buffalo, black buffalo, gizzard shad and golden shiners. It is certainly unusual to find a good bass spawn under such conditions, but it does happen occasionally.

In early July, 1948, Wallace L. Anderson, Regional Biologist of the Soil Conservation Service traveled with me to Ridge Lake, near Charleston, Illinois, to test the "balance" of the fish population of this lake by using the minnow seine method. We seined rather extensively and caught many yearling bluegills, a very few bluegill fry and no young bass. This was, according to the interpretation of the minnow seine method, a lake over-crowded with bluegills. Yet our complete creel census on Ridge Lake for 1948 showed a bass catch of 366 legal and 282 illegal bass (illegal fish removed as caught), or a yield of 25.6 pounds per acre. At the same time a yield of 45.8 pounds of bluegills per acre was recorded.

In the summer of 1947, Mr. Wallace L. Anderson and Mr. H. S. Swingle made a trip through Ohio, Indiana, Illinois, Missouri, and Iowa that covered a period of two weeks, to test the minnow seine method in ponds in those states. In each state they met with U. S. Soil Conservation Service men and demonstrated the method. In the two weeks they tested 116 ponds. Allowing no time for travel, they must have made tests on 8 ponds per day for 14 days plus 4 additional ponds. Obviously no time was available to check their findings by using sampling equipment other than a minnow seine, and no attempt was made to test the validity of their statement.

In 1948, Wallace L. Anderson arranged a trip with several members of the Aquatic Section of the Natural History Survey to sample ponds in the region of Vienna, Illinois. Several members of the Illinois Department of Conservation were invited, including the local Conservation Officer who knew something of the fishing that the ponds produced. The procedure followed was to make minnow seine collections for predicting the condition of the fish population, then to follow this with a haul using a 100-yard, 1-inch mesh seine to see what adult fish could be captured. Practically all of the ponds indicated "balance." Hauls with the larger seine frequently brought up quantities of bluegills of relatively small sizes (4.5 to 5.5 inches) that hardly could be considered large enough to interest fishermen. Comparatively few large bass were taken. Local information on fishing indicated no consistent correlation with minnow seine predictions—some ponds were "good"; others were very poor. In all, about 12 ponds were tested by Anderson and party over a period of three days. Several others were tested by our crews later. None of our party was convinced of the ability of anyone to predict the size of fish or the kind of fishing that a pond would produce from the minnow seine method. I see no point in telling a farmer his pond is in "balance" if no fish can be caught or if those caught are not suitable for table use. Anderson, who was a firm believer in the minnow seine method in 1948, was asked to recommend management procedures for the ponds after they were sampled with the minnow seine; these statements were recorded by D. F. Hansen and Guy Bellamy. Later, after Anderson had seen the results

of the haul with the 100-yard seine, he was often forced to change his original recommendation or to "hedge" on his original statements. The 100-yard seine is admittedly a poor piece of gear for sampling the fish population of a pond, regardless of its size, but it is certainly of more value than a minnow seine.

On the second page of Phillip Allan's comment, he states, "Because a relatively large proportion of the poundage of fish in ponds showing 'balance' by the method in question are of 'keeping size,' the fishing is usually good." In the series of ponds tested by Anderson and our party, it was found, as stated previously, that many contained dominant numbers of bluegills ranging in length from 4.5 to 5.5 inches. These fish, in my opinion, are too small to interest anglers. The variation in adult fish populations both from the standpoint of average sizes of individuals and in the relative numerical ratios of bass and bluegills, that will give a "balance" analysis by the minnow seine method, is so great that the test has little real value, and as shown in the case of Ridge Lake, it may give an opinion regarding a fish population that is seriously in error.

Allan's final statement: "To date the minnow seine method has proved the most useful technique in analyzing farm ponds on a large scale, and its accuracy has not yet been seriously challenged" should be changed to, "To date the minnow seine method has proved a useful technique to keep farmers interested in their ponds, but its accuracy has not been proven."

I have found no published information (an adequate series of experiments in which minnow seine analyses were followed by draining or poisoning censuses of the adult fish populations) that proves the value of the minnow seine method; neither have I found evidence in my own experience to suggest that is has any real value.[1]—GEORGE W. BENNETT, *Natural History Survey, State of Illinois, Urbana, Illinois.*

[1] Since the above was written, Fessler (Progressive Fish-Culturist, 12: 3–11, Jan. 1950) has reported on fish populations in 20 Iowa ponds where both the Swingle minnow seine method and the Petersen marking and recovery method were employed. He reports disagreement between the two methods in many cases, but concludes that there is "a moderate amount of agreement." Ed.

REVIEWS

Wildfowling in the Mississippi Flyway, edited by Eugene V. Connett. D. Van Nostrand Company, Inc., New York, N. Y. 387 pp. illus. 1949. $12.00.

This book was produced for the died-in-the-wool duck hunter, who will certainly receive it favorably. Sixteen of the 21 chapters are devoted to descriptions of the waterfowl hunting in three provinces and thirteen states in the Mississippi Flyway. Virtually every one of these state and province chapters contains historical accounts of the "good old days," with records of the quality of shooting which occurred in previous decades, of famous marshes which, in many cases, have been destroyed, and of changes in wildfowling conditions in the area described. The wildlife technician will enjoy reading this book, whether or not he is a hunter, because it does contain a great deal of valuable information which it is difficult to secure in the ordinary sources.

Of special interest and significance is the extent to which the findings of trained waterfowl investigators have been incorporated into a work written primarily for the hunter. There is considerable evidence in this book that wildlife management is gradually coming of age, and exerting more influence upon the gunner. The Indiana chapter, for example, by W. B. Barnes, describes the waterfowl investigations of the Indiana Pittman-Robertson Wildlife Research Project, in addition to giving an excellent historical account of wildfowling in the state, together with an interesting account of modern waterfowl conservation activities in that state. The Illinois chapter, by Kenneth Smith, likewise, quotes generously of the findings of the Illinois Natural History Survey, real pioneers in waterfowl research. The book is spotty in this respect, however, because

Jimmy Robinson's account of Manitoba dwells upon little else than his own hunting experiences in the province, mentions the outstanding work of the Provincial Game Branch under G. W. Malaher only in passing, and completely ignores the Delta Waterfowl Research Station which over the years has become an outstanding center of waterfowl research. This onesidedness is regrettable for both gunner and conservationist, because the impression is given that the water fowl production of Manitoba has continued undiminished over the years. Fortunately, few of the chapters are as unbalanced as this.

Of particular interest to the waterfowl manager are the chapters on the Mississippi Flyway, by Frederick Lincoln; the Mississippi Flyway Breeding Grounds, by B. W. Cartwright; and especially the chapter on Research on Wildfowl, by Kenneth Smith. This latter chapter gives the research man a very encouraging tribute. In addition to considering the needs for research, some of the outstanding problems, and the contributions research has made and is making to waterfowl conservation Mr. Smith quotes a good many current findings of the Illinois Natural History Survey waterfowl research staff which have not yet appeared in print elsewhere, and will be of real interest to the technician.

Unfortunately, the price will place it out of reach of many otherwise interested readers, but they should make it a point to consult the book where available, because they will find an evening spent with it of more than passing interest.—GUSTAV A. SWANSON.

The Saga of the Waterfowl by Martin Bovey. Wildlife Management Institute, Washington, D. C. 140 pp. illus. 1949. $5.00.

"The Saga of the Waterfowl" is an exceptionally beautiful and effective book. It is essentially a picture book, of 71 carefully selected photographs, each illustrating a very brief text on the page facing. The story of waterfowl in America is told very effectively in these few words, however, from the time of primitive abundance, through the decades of decline caused by man's destruction of the birds and their habitat, and the years of drought; finally describing efforts at restoration, and concluding with a penetrating question to the reader to decide for himself whether these efforts are adequate.

The carefully selected photographs, mostly by the author himself, prove that he is an artist. The literary quality of his prose, proves that he is a poet at heart. And the content of the story he has told proves that he is a real conservationist with a sound grasp of the problems which face us in waterfowl management. No one with the slightest interest in wildlife can fail to enjoy this volume.—GUSTAV A. SWANSON.

Second Annual Report of the Severn Wildfowl Trust, 1948–1949. Country Life Limited, 2–10 Tavistock Street, Covent Garden, London, W.C. 2, England. pp. illus. 7*s*.

This attractive report deserves notice here for at least two reasons, the activities it reports, and its appendix. The Trust itself should be better known to American waterfowl investigators, because it bids fair to become one of the outstanding waterfowl research centers in the world, and the present report contains much of interest to wildfowl investigators everywhere. Under the vigorous leadership of Peter Scott, the Trust has accomplished much in the two years of its existence.

The report is illustrated with many drawings by Peter Scott, a beautiful full-color cover of the geese he paints so well, and 24 pages of handsome photographs reproduced in photogravure of many species of waterfowl in the collection of live birds, as well as a number of scenes which illustrate clearly the facilities available to the Trust.

The report contains an appendix entitled, "Key to the Wildfowl of the World," by Peter Scott, which will be of outstanding interest to waterfowl students. It consists of wash drawings of all of the waterfowl of the world arranged and named according to the classification of Delacour and Mayr in the *Wilson Bulletin* for March, 1945. To the American biologist, the term "key" has acquired such a specialized meaning that this useful publication might best be understood if described as an illustrated check list of the wildfowl of the world, including a brief description of the range of each form, and a few of the recognition characteristics listed on the 23 plates of drawings. The Trust has recognized that this appendix will be in wide demand by making it available in booklet

form at the price of two shillings and sixpence from the Severn Wildfowl Trust, Slimbridge, Glos., England.—GUSTAV A. SWANSON.

Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources. Denver, Colorado, September 7–20, 1948. Washington, D. C., Department of State Publication 3382. xi+782 pp. illus. 1949. ($2.50—Government Printing Office.)

After study by the Pan American Union, the first international conference on conservation was held under the auspices of the United States government in 1948; 20 nations sent delegates and experts whose 111 papers (in English) make up the present volume. Eleven titles are on human population pressure and the productive capacity of the land, and 19 on land use and the social sciences. These state the problems. For the most part, the remaining papers look to solutions; 11 are on renewable resources and international relations, 40 cover technological methods in hemisphere conservation work, 16 are on education, and 16 are in a final section devoted to "making conservation effective." This official breakdown is by no means a completely accurate one, but it does sum up the scope of the conference and the type of material in the Proceedings.

Among the U. S. contributors are H. L. Shantz, H. H. Bennett, W. R. Chapline, W. P. Cottam, N. B. Drury, E. R. Kalmbach, O. J. Murie, G. A. Swanson, C. C. Adams, J. V. K. Wagar, A. H. Carhart, H. J. Coolidge, I. N. Gabrielson, and S. F. Olson, all of whom are known to many members of the Wildlife Society. Less well known to us are the leading agronomists, anthropologists, bankers, chemists, demographers, economists, engineers, foresters, geographers, historians, hydrologists, political scientists, and range managers whose comments and data broaden the horizon of this book and enrich its pages for the reader.

A number of Latin Americans contributed papers on original research in these *Proceedings*. Most of the authors, however, summarize ideas, experiences, problems, and techniques that—for the most part—are well known to specialists. Perhaps nowhere, however, have so many of them been so compactly expressed and with such authority. To Latin Americans, this book (in its Spanish edition) is bound to become a land mark in conservation; wildlife workers in North America will find in its useful, cogent, and stimulating summaries of problems encountered in related fields. Thus Chapline highlights recent research on grazing management and range reseeding, Kotok convincingly emphasizes the necessity for an ecological rather than a purely economic basis for silviculture, and Warne discusses the legal and economic aspects of excessive use of ground waters in the United States.

The *Proceedings* represent an interesting document at a time when writers about the future of renewable resources are being catalogued as optimists, pessimists, realists, and the like. The Conference contained its share of each. One finds in this volume the Honorable Harry S. Truman discussing the good-neighbor policy of the United States with these words: "If we can just continue that sort of feeling, there isn't any question of a doubt in my mind that our natural resources will meet the population's demand no matter what they may be." This type of thinking was a rarity at the Denver Conference. (It is in fact no thinking at all.) At the opposite extreme are Leonard Outhwaite's statement of the shocking conservation problem on Navajo lands in our own Southwest, and Pacheco and Martinez's dramatic account of the depletion of natural resources in El Salvador—a mountainous country with the population density of India.

However convenient it is to newsmagazine thinkers, this classification of optimists and pessimists fails as a critical description of the recent divergences in conservation thinking. What we have today are, on the one hand, the convictions of some scientists that the future is not alarming because a sufficient knowledge of techniques now (or will soon) exist to place the world's use of natural resources on a sustained-yield basis and, on the other hand, the awareness of many conservationists that technological success must be preceded or accompanied by social, cultural and economic revolutions which in many countries assume a stupendous character.

The conservation problem is thus not

merely the management of some resources but the management of man himself. This point is repeatedly driven home by various authors in the *Proceedings*. H. L. Shirley, for instance, lists 11 technical obstacles to sustained-yield forestry—and 22 social, political, and economic handicaps. It is the great merit of this book that these handicaps, or ones similar to them, are analyzed by specialists experienced on the study of human interrelationships. The Conference squarely faced the problem of population pressure, and in general documented the thesis propounded by Vogt in his *Road to Survival*. On the population score, it did not offer solutions. In the matter of the effect of government stability on conservation programs, it also preserved a diplomatic silence. In spite of this, the book remains a fascinating one to read. The papers give every appearance of having been smoothly edited, and my one regret is that the volume lacks a subject index.—JOSEPH J. HICKEY.

Principles of Animal Ecology. By W. C. Allee, A. E. Emerson, O. Park, T. Park, and K. P. Schmidt. W. B. Saunders Company, Philadelphia, Pa. 1949. 837 pp., 263 figs. $14.00.

This monumental work is a real milestone in the progress of ecology, one which will do much to raise it to new heights of prestige as a science. Many students, the reviewer among them, have found most ecology texts unsatisfactory in many ways—addicted to an unnecessarily complex and confusing terminology, unduly emphasizing the authors' limited personal interests and experience, and lacking in definiteness. These criticisms do not apply to the present work and let us hasten to add, neither to the fine books by Elton of about two decades ago.

Those engaged in wildlife research will find the volume an invaluable reference work, because for the concepts and principles of animal ecology which it discusses, it includes in all cases concrete samples of the evidence upon which they are based. These are drawn from all aspects of biology. Contributions of the forester, wildlife researcher, fishery biologist, and range specialist are among those from applied fields which have been used generously. The bibliography itself, of about 2500 references, is a valuable contribution.

The volume contains sections on the history of ecology, analysis of individual environmental factors, populations, the community, and ecology and evolution. Perhaps the section on populations will be of the greatest interest to wildlife students. In it they will find valuable discussions of the properties of animal populations, of census methods, of many types of population studies on all classes of animals from protozoa to man, on various aspects of reproduction, types of population fluctuations and their causes, and many others. In short, the volume is destined to occupy a prominent place on the reference shelf of any wildlife research man who is studying ecological problems, and particularly animal populations. The comprehensive nature of the volume would have been impossible without a close type of teamwork which is all too rare. Ecologists throughout the world owe much to each of the five authors of the present work for their invaluable contribution.—GUSTAV A. SWANSON.

Raising Game Birds in Captivity. By David B. Greenberg. D. Van Nostrand Company, Inc., New York, New York. 1949. 224 pp. illus. $4.95.

While the trend away from stocking with game farm birds is a steady one in wildlife management, and properly so, there will always be a considerable number of persons interested in artificial propagation of game birds. It seems clear that the State Game Departments are gradually withdrawing from the pheasant stocking business, but the commercial demand for game birds to stock private shooting preserves, and for direct sale as food, continues and may even increase somewhat. For those persons who are interested in raising game birds, this book is a valuable, up-to-date manual. The author has gathered together in one volume information which was widely scattered in many research bulletins and papers in the technical journals, so that the uninitiated can quickly locate the pertinent results of work by such well known investigators on pheasants and quail as Stoddard, Romanoff, Latham, Nestler, Callenbach, Coleman, Wight, and many others. The author is more temperate than most writ-

ers of this type of work in his enthusiasm for game farming. He recognizes the need of suitable habitat, and even states definitely that game farming does not offer opportunities to "get rich quick."

Greatest attention is given to pheasants and bob-white quail, but brief sections are devoted to the chukar and Hungarian partridges, the wild turkey, and ducks and geese. Chapters on artificial incubation, brooding, nutrition, and wing clipping all quote profusely from recognized authorities. While written for the novice who is interested in experimenting with game farming, the book is not without value to the wildlife manager on those occasions when he must cope with some of the technical questions of game farming. Since obvious errors are relatively few, it is conspicuous that on page 2 an attractive full-page cut of blue geese is labeled "wild duck." —GUSTAV A. SWANSON.

The Game Birds in Hawaii. By C. W. Schwartz and E. R. Schwartz. Board of Commissioners of Agriculture and Forestry, Territory of Hawaii. 168 pp. illus. 1949.

The reader of this attractively-presented account cannot help but wonder how the authors could possibly gather so much information in eighteen months' time. The survey, conducted from February, 1946, through July 1947, was the "initial step in the Federal Aid-Wildlife Program (1-R) of the Division of Fish and Game, Board of Commissioners of Agriculture and Forestry." The report is packed with interesting information, and is lavishly illustrated with photographs and drawings by Charles Schwartz. Each species account contains several sections, including descriptions of the distribution and populations, the life history in Hawaii, sex and age ratios, parasites, predators and illegal kill, food and water requirements, management recommendations, and a list of the important references. Many a game survey in this country, upon which much more time and effort has been expended, would have just cause for pride if the results were presented in as attractive and useful form as these.

The American reader will be particularly interested in the extent to which birds familiar here are established in Hawaii: pheasants, California quail, the feral pigeon, chukar partridge, and lesser prairie chicken. Some of these are thriving, others are not established with certainty. Readers of the JOURNAL will want to secure this publication, both for the interesting information it contains, and as a fine example of presentation of game survey data. GUSTAV A. SWANSON.

The Way to Game Abundance: With an Explanation of Game Cycles. By Wallace B. Grange. Charles Scribner's Sons, New York, N. Y. 1949. 365 pp., illus. $6.00.

Grange set himself an ambitious task—that of presenting in non-technical terms the biological background that the intelligent sportsman needs to understand game management problems, and of furnishing an explanation of game cycles. In the first of these ambitions he has succeeded remarkably well; and in attempting to explain the small-game cycle he has made an important contribution to our thinking, one which future students of cycles can ill ignore.

Parts I and II discuss the biological background, with special emphasis on habitat and succession. These chapters are good ecology; they provide a sound perspective on predation, and consistently emphasize the controlling influence of plant succession.

The discussion of population cycles (Part III) is of special interest because it treats a problem which has confounded biologists since DeLury and Elton launched the sunspot influence controversy in 1923–24. Grange defines "cycle" simply as "an interval of time occupied by one round of events recurring in the same order in a series." He thus stresses the orderly sequence of events but does not require that the interval be constant and therefore implies no necessary periodicity.

Briefly, his explanation of game cycles may be stated thus: Snowshoe Rabbits, for example, thrive during that particular developmental stage in the plant succession which provides maximum food and shelter; given these optimum conditions, their high biotic potential leads to a rapid increase in numbers, and population pressure causes overflow into surrounding areas. Grange calls an area with such favorable conditions a Natural Propagation Area because its overflow will

build up the rabbit population of adjacent areas; given enough such areas, we have the makings of regional abundance of Snowshoe Rabbits. But when the natural sequence of plant succession has passed the most favorable developmental stage, both food and protective cover grow scarce, the rabbits become exposed to a variety of decimating factors, and the population declines. No return to abundance is possible until some disturbance (usually fire, in Grange's experience) sets back plant succession to an early stage and reproduces the optimal conditions.

At first thought, many technically trained readers may scoff at Grange's simple explanation, particularly in the outline form presented here, but they owe it to themselves, and to the author, to read his account in full. The reviewers feel that the thoughtful student must conclude that Grange has been exceptionally successful in demonstrating the importance of plant succession.

In attempting to account for the simultaneity of the cycle over wide areas, Grange stresses fire as the greatest initiator of plant succession, and he quotes Morris (*Fire, Control Notes*, 8: 4, 1947) to demonstrate that forest fires, at least in Wisconsin, have occurred in cycles and that "nearly all of the great fires in the State occur during periods of declining sunspot activity." It has been widely held that weather varies with the sunspot cycle, but to the reviewers' knowledge, Grange is the first to emphasize the complex chain of events: sunspot influence—drought—fire—plant succession—game population changes.

Near the close of his section on cycles, Grange writes: "Perhaps the greatest unsolved riddle of the northern small game cycle is why this has shown, for the last century, an apparent regularity of about ten years, whereas the sunspot cycle shows no such regularity, and averages slightly more than 11 years. Obviously, the two cycles do not coincide entirely; there remains a distinct and important gap in our understanding of such details. This technical point (and a considerable number of others) must await further research. . . ." Grange has not "explained" the problem of cycles (he pays no attention to the 3-4 year cycles of the arctic, for example), but his ingenious exposition should persuade biologists who, ever since MacLulich and Elton discounted sunspot influences, have looked elsewhere for a solution, to reinvestigate this problem from the viewpoint of habitat and succession. Perhaps a study of Tannehill's stimulating little book, "*Drought* Its Causes and Effects" (Princeton, 1947), would help eliminate some of the difficulties that have plagued all students of animal cycles, because, while this book does point out the relationship between drought and sunspot cycles, it is far more successful than biologists have been in accounting for apparent inconsistencies.

Wildlife researchers will possibly be chiefly preoccupied with the portions which relate to cycles, but the fourth and last part of the book, on "The Technology of Game Increase," is both interesting and valuable. The longest and most stimulating chapter in this section is entitled, "Controlled Burning for Game." Not since Stoddard's pioneering work with controlled fire for quail management in the South, has any wildlife investigator summarized so usefully, and from such a fund of personal experience, the possibilities of fire for game management. Several of the other chapters in Part IV will be of interest to the wildlife technician, even though it is plain that they were written primarily for the sportsman.

One cannot help but speculate about the reception of such an effort. The general public, accustomed to a fare of picture magazines, may find it a bit solid, even though it is highly readable. The scientific reader will object to the complete lack of documentation, and a lack of respect for inconsistencies which do not fit into the author's explanation. But both groups will find it stimulating and valuable.—ROLAND C. CLEMENT AND GUSTAV A. SWANSON.

North American Waterfowl. Albert M. Day. Stackpole and Heck, Inc., New York, N. Y. 329 pp. illus. 1949. $4.75.

In a book aimed primarily at sportsmen, Al Day has managed to pack so much valuable information that the professionals in wildlife management will find much of interest in it. He has succeeded admirably in making the story of waterfowl conservation in the United States one rich in human interest. The book

is an attractive one in every way, generously illustrated with line drawings by Bib Hines, with photographs, and with a full set of halftone reproductions of the duck stamp paintings. Al Day proves to be such an eloquent waterfowl conservationist, that the sportsman who takes the book in hand is not likely to lay it down before finishing. Not only will he learn a great deal about waterfowl, which will help him to understand the measures which must be taken to protect them, but he will find much enjoyment in the process.

Beginning with a brief historical account of early shooting conditions, the decline of waterfowl, and the development of conservation measures such as protective legislation, the book continues with discussions of bird migration, the flyway concept, the annual inventories of waterfowl populations, the annual hunting regulations and how they are enforced. A very interesting chapter entitled, "Wildlife G-Men," gives a real insight into the problems of game law enforcement and describes a number of case histories of the apprehension of violators.

One of the important features is the generous acknowledgment given to the many agencies which participate in the international waterfowl conservation Program. There are chapters on the activities of the states, both before and after the Pittman-Robertson Program became established; on "Waterfowl Conservation in Canada"; a particularly interesting chapter on "The Mexican Waterfowl Situation"; and one on private conservation organizations and the part they play.

Every waterfowl hunter owes it to his sport to read Day's book. If it enjoys the wide sale it deserves, this book will play a very important part in educating the public in waterfowl conservation matters—one of the greatest needs in the field today.—GUSTAV A. SWANSON.

Danish Review of Game Biology. Edited by Jagtraadets vildtbiologiske Undersgelser; managing editor. R. Spärck, Zoological Museum, Copenhagen. J. H. Schultz, Ltd., Copenhagen.

American wildlife investigators have generally been poorly informed on wildlife research abroad, so this recently initiated serial will be of special interest since its apparent intention is to present in the English language the results of extensive researches in Denmark into the biology of game animals and other wildlife of economic interest.

Volume I, Part 1, which appeared in 1945, consists of a single paper, 110 pages in length, by Holger Madsen, entitled, "The Species of *Capillaria* Parasitic in the Digestive Tract of Danish Gallinaceous and Anatine Game Birds." Volume I, Part 2, the latest one issued, contains two papers, the first by Marie Hammer, entitled, "Investigations on the Feeding-habits of the House-sparrow (*Passer domesticus*) and the Tree-sparrow (*Passer montanus*)." This is a comprehensive study (of 59 pages) which summarizes the food habits of the two sparrows in Denmark as revealed by extensive stomach examinations and comparing them carefully with the work in the British Isles by Collinge, and that in the United States by Kalmbach. The other is a brief paper by M. Christiansen and Holger Madsen entitled, "*Eimeria bucephalae* N. Sp. (Coccidia) Pathogenic in Goldeneye (*Bucephala clangula* L.) in Denmark."

Since the described intention is to summarize more than ten years of investigations on the food and parasites of Danish game birds which have been conducted for the Department of Agriculture and Fisheries, it seems clear that all American institutions maintaining libraries in the wildlife research field will wish to acquire this serial from the beginning.—GUSTAV A. SWANSON.

A Game Inventory of Alabama. By Frederick S. Barkalow, Jr. Alabama Department of Conservation, Montgomery. 140+x pp., illus. 1949.

The war ended this three-year Pittman-Robertson project after 32 months, in June 1942. Considered primarily were numbers and distribution of quail, turkey, deer, and beaver, but also "it was desired to determine the following for each species of Alabama game animal: (1) Limiting Factors . . . (2) Restoration . . . (3) Research Problems. . . ." This suggests that there may later be another paper, for this one treats almost entirely distribution, census, numbers, and population trends. Quail receive 38 pages, turkeys 13, deer 8, beaver 17, waterfowl 9, rabbits 4,

gray and fox squirrels 5, and twelve other species (mourning dove, opossum, gray and red foxes, raccoon, bear, muskrat, striped and spotted skunks, mink, otter, and bay lynx) an average of 9 lines each plus a three-point graph showing the 1938–1942 trend as judged by the 39 game wardens. The Inventory was conducted by "a project leader, four research assistants, a secretary, and from one to three part time assistants," with help also from conservation department personnel. An average of 27 usable farmer-questionnaires per county were obtained in 1940.

For quail census, the author depended upon dogs and questionnaires. The former method "is as economical as any that gives results of comparable accuracy." The farmer-questionnaire method he found tedious, expensive, requiring trained men, and limited to inhabited areas; it did provide, however, for personal appraisal on the spot. Warden-questionnaires were extensively used; he concluded that wardens report trends more reliably than farmers do. Drives were tried but would have been prohibitively expensive on a statewide scale. Also he used the whistling of unmated cocks; "this method was not employed to obtain data on a statewide basis, but it could be used for this purpose." Estimates from dog censuses and questionnaires agreed rather closely, considering the differences in season.

His method of expressing trends is open to question, for he uses the difference between the number of counties reporting increase (warden questionnaires) and the number reporting decrease, without considering the total sample or the number reporting the species stable or absent. Thus the same value, +19, is given to both rabbits (increase 35, no change 16, decrease 16) and deer (20:8:1); it could be applied equally well to theoretical cases of 38:0:19, 38:38:19, 19:19:0, or 19:0:0—cases which, to this reviewer at least, would not indicate the same fluctuations.

He found 1,085,000–2,294,000 quail and, by the Mosby-Handley method, 11,600 and 13,500 turkeys in the spring and fall of 1940. Farmer-questionnaires indicated the presence of 16,000 and 14,000 in the same periods. Personal investigation found 1,000 beaver in 1940, 3,500 in 1941.

It is too bad that these figures were not published soon after the war at least, for in seven years almost anything can have happened—particularly these last seven years. However, it is to be hoped that the Alabama Conservation Department has based many of its practices since 1942 upon this study, and that there will be another publication treating ecology, land use, and other subjects not covered by this one.

Incidentally—for there are no doubt good reasons—the reviewer wonders why Mr. George C. Moore, who supervised this project for 13 of its 32 months, was recognized by only a one-sentence credit line.—RUDOLF BENNITT.

OBITUARIES

CHARLES TAYLOR VORHIES

1879–1949

For many years biologists or field investigators in the fields of entomology, ornithology, mammalogy or plain desert ecology in Arizona and the Southwest have made a bee-line for the office of Dr. Charles T. Vorhies of the University of Arizona, Tucson. There they were perfectly sure to find sympathetic and well-balanced advice, a well-tempered enthusiasm for finding out more about the animals of the desert, and as often as not, a willingness to take off into the field with the visitor so as to facilitate his contacts with the country.

To a host of Dr. Vorhies' friends and acquaintances, the days of March 1949 were saddened by his sudden illness and death (March 11, 1949) while attending, with Mrs. Vorhies, the Fourteenth North American Wildlife Conference in Washington, D. C.

Born on a farm in Henry County, Iowa, Dr. Vorhies became interested in zoology at Iowa Wesleyan, where he took his B.S. degree in 1902. His Ph.D. was received at the University of Wisconsin in 1908. According to Wildlife Research News Letter No. 27 (processed), page 3, of the Department of Wildlife Management, University of Wisconsin, Dr. Vorhies was the first man to receive the Ph.D. in Zoology from the University; but Dr. L. P. Wehrle, his close associate at Arizona for many years, says he took his degree at the same time with R. W. Hegner, the latter receiving the degree first by a few minutes as they moved across the stage in alphabetical order.

Dr. Vorhies' first full-time appointment was at the University of Utah, where he was professor from 1908 to 1915.

He became Assistant Professor of Biology in the University of Arizona in 1915–1916. From this date forward until his death he remained at Arizona, where official University records depict his career as follows:

Assistant Professor of Biology—1915–16
Professor of Zoology—1916–17
Professor of Entomology and Entomologist in the Agricultural Experiment Station—1917–22
Professor of Entomology and Head of the Department of Biology, and Entomologist in the Agricultural Experiment Station—1922–26
Professor of Entomology and Head of the Department, and Administrative Adviser 1927–28
Professor of Entomology and Head of the Department of Biology, and Entomologist in the Agricultural Experiment Station—1928–30
Professor of Entomology and Head of the Department of Entomology and Economic Zoology, Entomologist in the Agricultural Experiment Station, and Curator of Zoology—1931–34
Professor of Zoology and Head of the Department of Entomology and Economic Zoology, and Economic Zoologist in the Agricultural Experiment Station—1935–36
Professor of Zoology and Head of the Department of Entomology and Economic Zoology, Economic Zoologist in the Agricultural Experiment Station, and Curator of Zoology in the Arizona State Museum—1937–49

His fields of work and interest, as listed in American Men of Science (1938, p. 1474), were economic zoology and entomology; Wisconsin Trichoptera; fauna of Great Salt Lake; economic insects of Arizona; grazing range rodents; ecology of desert animals.

Dr. Vorhies' scientific organizations included the American Association for the Advancement of Science, Entomological Society, Society of Ichthyologists and Herpetologists, American Society of Mammalogists, Ecological Society, Wildlife Society, American Ornithologists Union, and Cooper Ornithological Club.

But how little such a list gives on the actual organizational work of a man like Vorhies! More than generous with his time

and interest, he was frequently called on to serve as officer or committee member for one or another of these societies, always acquitting himself with credit.

Dr. Vorhies' principal organizational activities do not appear at all in the above list He was always active in the Arizona Game Protective Association, later called the Arizona Wildlife Federation. In fact, President William H. Carr of that organization writes, "Dr. Vorhies *was* the Arizona Wildlife Federation, in person!" For years he acted as Secretary-Treasurer, writing its bulletins and performing all the organizational drudgery which goes with that kind of job.

Latterly he became active in the National Wildlife Federation, in which he served as Chairman of the Committee on Conservation Education and also as Vice President and member of the Executive Committee. President Dave Aylward says Dr. Vorhies never missed a meeting of the Federation or of the Executive Committee, travelled extensively, and spent untold hours with the work of the Committee on Conservation Education.

Probably as close to Dr. Vorhies' interest as any organization was the Tucson Natural History Society. Founded March 3, 1923, by Dr. Vorhies and the writer, the Society has flourished through all these years and is still going strong. Dr. Vorhies led many field trips which took members far and wide over Arizona and nearby Mexico; he served at various times in all the offices of the Society. His lecture on "Poisonous Animals of the Desert" was given year after year and always was enthusiastically received. His audiences were always wide-awake, especially when, as occasionally happened, one of the live rattlers he was handling dropped to the floor. A few years back he was deservedly made a Life Member of the Society.

The writer's first meeting with Dr. Vorhies was on April 5, 1918, when we met through the intervention of Dr. Frederic E. Clements, of the Carnegie Institution of Washington, who then lived in Tucson. On that date began a close friendship as well as a somewhat official cooperation which has lasted to the date of Dr. Vorhies' death. The memories are priceless of many pleasant hours in the field and of enjoyable and productive conferences on conservation and desert ecology, not to mention personal bull sessions perhaps even more enjoyable. As Dr. Wehrle has pointed out in a letter to the undersigned, Dr. Vorhies possessed a marked native wisdom and thriftiness, and not a little humor perhaps derived from his Scotch-Irish-Dutch ancestry. He conceded that his ancestors did not come over in the Mayflower, but in the Spotted Cow. No one could have made a more felicitous camp companion, nor a more considerate co-author—the latter often an acid test of character!

But let no one overlook Dr. Vorhies' courageous and insistent interest in virtuous action, whether in the sometimes devious connivings of a university or in the exploitive tendencies of all too many of our dominant business groups. Always Dr. Vorhies stood four-square for academic freedom, for conservation, and for strenuous opposition to every form of special privilege and exploitation, especially as affecting the basic production natural resources—minerals, soils, waters, range forage, forest, wildlife.

The attached list of Dr. Vorhies' scientific publications gives significant indication of the breadth of his intellectual interests. Note that the first paper, published in 1905, dealt with the caddis-fly; the last, published in 1948, with the food of rattlesnakes. His contributions embrace work not only on insects but on birds, rodents and other mammals, economic insects, reptiles, and desert ecology. On the latter important subject his work and interest culminated, although it continued full-speed ahead, in his Presidential Address to the Ecological Society of America, given at the Annual Meeting, Columbus, Ohio, December 27, 1939, on "Progress in Desert Ecology", unfortunately never published.

In Dr. Vorhies' death there passes an outstanding scientist, conservationist and leader, whose working presence we can ill spare. But more than that, we have lost a generous, kindly friend and co-worker, a man! May his inspiring example help us to carry on without stint in the fields of intellectual and human interest in which he was so distinguished a worker.—WALTER P. TAYLOR.

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HENRY VAN CLEVE
1870–1948

Henry (universally known as Harry) Van Cleve, a Charter Member of The Wildlife Society, was born at Coudersport, Pennsylvania, September 7, 1870. A life-long naturalist, he early took a special interest in trapping and, broadly speaking, that was the field of most of the activities of the remainder of his career. His employment record shows

that he was with the Goodyear Lumber Company (1889–1905), Lackawanna Lumber Company (1906–1911), Pennsylvania Forestry Department (1912–1916), Pennsylvania Game Commission (1916–1936), and the Animal Trap Company of America (Lititz, Pa., 1936 until his death). With the Game Commission, he served as Refuge Keeper, County Game Protector, State Trapping Instructor, and in charge of bounty claims. In 1920 he began the project that resulted in re-establishing the beaver as a commercial fur animal in Pennsylvania. The Animal Trap Company employed him to conduct its trappers' service and information bureau. His life-long experience was summarized in a book "Trapping" (co-author, Harold McCracken) that was published by A. S. Barnes & Company (New York City) in 1947.

Mr. D. S. Morrison, Sales Manager of the Animal Trap Company (to whom I am indebted for most of the information here presented) says of our subject, "I had the pleasure of working with Mr. Van Cleve for approximately ten years and was always impressed by his vast knowledge of wildlife and conservation problems. He was always willing and eager to share his knowledge of wildlife with anyone who asked his advice. Although Mr. Van Cleve had no children of his own, he took great delight in explaining the outdoors to any and every small boy that he came in contact with. I have watched him at exhibits which our Company conducted where he went out of his way to see that the children were all furnished with answers to their questions. While working for us, he received many letters from boys and girls regarding trapping and the outdoors. He personally answered every letter and made sure that a complete answer was furnished. He felt that if every boy and girl were given the proper guiding in their youth that they would grow up to be true sportsmen and conservationists."

Mr. Van Cleve died from cancer, May 11, 1948, and was buried at Harrisburg, Pennsylvania. A brief sketch and photograph of him appeared in the Pennsylvania Game News for February 1949 (Vol. 19, No. 11, p. 11).—W. L. McATEE.

FREDERIC COLLIN WALCOTT
1869–1949

Frederic C. Walcott, one of the most colorful and loved men in the broad field of conservation, passed away in his sleep early during the morning of April 27, 1949, at Stamford, Connecticut. He was a world traveler from early young manhood to a few years ago. He explored every continent and joined many expeditions into the wilds of Asia, Central and South America, and other parts of the world. He was a statesman because he never placed his own personal political interests ahead of his conception of what should be done for the public. He was a philanthropist giving from his means to many worth-while public and private organizations for the betterment of mankind. He was a true sportsman and because of his vast knowledge of wildlife which he gained through travel to all parts of the world, he became early identified with the conservation movement in this country and was a leader in it up to the time of his retirement in 1948, shortly after his 79th birthday. He belonged to practically every National conservation organization and many local groups and was on the Boards of many of them.

During the first World War he was an aide to Herbert Hoover who headed the U. S. Food Administration, of which he was a member 1917–1919. On account of the excellent service in Belgian and Polish relief work which he rendered during the period from 1915 to 1917, he was decorated with the Legion of Honor of France and the Officer's Cross of Poland. He was elected to the United States Senate in 1928 at the time Herbert Hoover was elected President and he served in the Senate from 1929 to 1935. During his tenure of office in the Senate he was a leader in the wildlife restoration program and in 1930 was made Chairman of the

Special Committee of the United States Senate on the Conservation of Wildlife Resources. The political complexion of the Senate changed in 1933 from Republican to Democrat but so conspicuous was his leadership and sincerity that he remained Chairman of the Committee, though a Republican, until he retired from the Senate in 1935. During his term of office in the Senate, representing the State of Connecticut, he was instrumental in obtaining the passage of the original Duck Stamp Act, a policy-forming program which has been of great benefit to the waterfowl restoration program. He originated and sponsored on the floor of the Senate much of the basic Federal wildlife legislation during his term. When the Taylor Grazing Act was before the committees for hearing, he insisted on amendments which gave some consideration to the wildlife resources on the public range, and it is on these slender threads which he was able to have inserted in the bill that conservationists base their plea for wildlife consideration today from the Grazing Service.

He was one of the founders and an early director of the American Game Association. He was the first President of the American Wildlife Institute and when it was succeeded by the American Wildlife Foundation, he became its President. The Wildlife Society elected him to Honorary Membership in 1948.

He was a conspicuous and influential figure at all conservation conferences and through his wisdom and knowledge of conditions and men, he was able many times to direct the thoughts of these conferences into the right channels.

Senator Walcott was a kindly and a real friend. He not only gave generously of his wisdom but also of his wordly goods. Of him it was said ten thousand, thousand times, "He is a grand man." He is survived by a son, William, a daughter-in-law, and several grandchildren.

The preceding statement is by Shoemaker, this supplement by McAtee. Frederic Walcott was born February 19, 1869, at New York Mills, N. Y., and was educated at Andover (Massachusetts) Academy and at Yale University where he received the A.B degree in 1891. Later, honorary degrees were awarded to him by Yale (A.M. 1917) and Trinity College (D.Sc. 1928). After some years of getting acquainted with the World, he engaged in manufacturing and investment banking (1907–1915) and was an officer or director of numerous corporations (until 1922).

Walcott served the State of Connecticut as a member of the Senate(1925–1927), President of the Board of Fisheries and Game (1923–1928), Chairman of the Water Commission (1925–1928), and as Welfare Commissioner (1935–1939). He was on the Executive Committee of the Carnegie Institute of Washington, and was Trustee for Bethune Cookman College (Daytona, Fla.), and Trinity College (Hartford, Conn.). He was Chairman of the Board of Trustees of the Jane Coffin Childs Memorial Fund for Medical Research and a Member of the Advisory Committee of the Human Welfare Group of Yale University.

This writer first met Frederic Walcott in the business period of his life when he was associated with Bonbright & Co. in New York City. Meeting him there, at the Horn Point Club, Back Bay, Virginia, and at his estate near Norfolk, Connecticut, I found him genial, energetic, intelligently interested in practical conservation, and entirely unspoiled by wealth which seemed only a factor enabling him to more good in the World. He was broad-minded and generous in his attitude toward people and he retained his powers unimpaired years beyond the "alloted span."

The remaining paragraphs have been contributed by Gabrielson:

"I had known the Senator for many years and had learned to like and enjoy him and his company very much. He made one rather lengthy trip with me in 1943. At that time he was well along in years but as active as many men much younger. We traveled together over much of central Alaska and I was constantly amazed at his wide knowledge and physical stamina.

"Once, when he got out of the car to go a short distance to the edge of a canyon to try to get a color picture of a few caribou, I got out and sat on a rock looking at plants and other material we had picked up previously. I looked up in a few minutes and

was amazed to see him going almost at a trot up a butte half a mile away. Evidently, he had seen something of interest. I watched and there was a great string of caribou coming down the ridge toward this point. He got there in time to get some pretty good pictures.

"When we were together, he busied himself sketching details of plumage of birds which I had collected. At other times, he did sketches of landscape, all of them wonderfully good. I have seen several paintings that he made from some of his sketches of Alaskan birds and know that they were excellently done.

"Needless to say, he was a good traveling companion. He had had a world of experience and his comparisons of scenery and forests and wildlife with those in other parts of the world were most interesting.

"I can particularly recall his delight in the magnificent scenery in Yakutat Bay which he said exceeded anything he had ever seen in any other part of the world. He thought it was the most magnificent panorama of mountain peaks and glaciers that he had ever seen.

"It didn't make any difference to him what sort of accommodations we found. He made the best of it. We got into some rather rough places at times on the trip but I never heard him complain or give any indication that he was not used to enduring this type of accommodations regularly.

"He made a hit with everyone he talked to and was one of the best conversationalists that I have ever been with.

"His relationship to the Fish and Wildlife Service, of course, was exceedingly friendly. I can't ever remember a time when he was not willing to help on a project that would advance the cause of conservation. I can recall distinctly his reaction at the time that baiting was abolished. At that time he was a member of a gunning club which had a property somewhere on the lower Potomac that depended entirely upon baiting. He didn't complain any about it and he thought that the abolishment of baiting was a good thing and he hoped that he never lived to see it restored. The club abandoned its lease on the property and gave up shooting at the place. This reaction was characteristic of the man. I never knew him to do a selfish or a mean thing or to serve any selfish interest."—CARL D. SHOEMAKER, IRA N. GABRIELSON, and W. L. MCATEE.

HARRY FREDERICK HARPER
1881–1949

Harry Harper, who died August 8, 1949, after a long illness, was in life a wealthy industrialist whose deep personal interest in wildlife research led to Michigan's high position in this field nearly two decades ago. His contributions in both leadership and funds, while among the most significant in the history of conservation, are not well known to the membership of The Wildlife Society, of which he was a Charter member.

One learns, therefore, with growing appreciation that this highly successful business man, philanthropist, and conservationist, Wisconsin born, moved to Michigan as a young man, and in the 1920's became President of the Michigan Division of the Izaak Walton League. Through this medium, he was instrumental in establishing the Institute for Fisheries Research, the Williamson Project, and numerous fellowships in game and fish research, all of which he supported liberally through personal funds. These grants-in-aid insured graduate training through the doctorate for several leading wildlife teachers and researchers, and set the pattern, at least in part, for curricula in wildlife management and ecology as we know them today.

Retrospect shows that Harry Harper understood the value of research in industry, and thus was able to extend this understanding to the field of game and fish management. Moreover, these contributions came during the critical early years of the modern conservation movement, when wildlife research was scarcely recognized in legislative assemblies, or indeed by many wildlife officials. It was not, therefore, as a searcher for facts or as a writer of papers, but rather as a warm, enthusiastic, and most liberal underwriter

of these things, that he set his imprint indelibly as a founder of the modern profession of wildlife research and management.

Harry Harper's services to the Izaak Walton League are among the most distinguished in its long, conservation-minded history. He was, over many years, President of the Michigan Division, member of the National Executive Board, National Treasurer, and an original Director of the Endowment Program. During the trying depression years, when dues sank to woefully inadequate levels he kept the League alive through personal donation of operating funds.

As Chairman of the Governor's land acquisition board, his leadership in buying up private property made possible, more than the efforts of any other man, the creation of Isle Royale National Park.

In personal qualities, Harry Frederick Harper was noted for his quiet enthusiasm and warm personality. He was a man interested in getting conservation jobs done, and worked unselfishly toward these ends, with no concern as to credit. It is not too much to say that every individual in the wildlife profession is indebted to him for his farsighted nurturing of research and management in this field during its infant days.

He is survived only by his widow, Mrs. Raga M. Harper, who resides at 1408 Cambridge Road, Lansing, Michigan.—LEE E. YEAGER, with generous assistance from MILES D. PIRNIE and SAMUEL A. GRAHAM.

FRANK ERNEST ALOYSIUS THONE
1891–1949

It is by many conceded that the most urgent need in the field of wildlife conservation is education on the utilitarian level. Dr. Frank Thone, who died August 25, 1949, served in this capacity perhaps more effectively than any other member of The Wildlife Society.

A botanist, with a lifelong interest in plant ecology, Dr. Thone's scope of activity far exceeded this branch of the biological sciences. In 1924 he joined the staff of Science Service and later became editor of its biological section. During the quarter century of his association with the Press, Dr. Thone, who listed the popularization of science as his principal aim in life, produced thousands of articles in the science field, the breadth of which is indicated by his coverage of the famous Scopes evolution trial at Dayton, Tennessee, in 1925, and the atomic bomb test at Bikini in 1946.

Following his graduation from Grinnell College in 1915, Frank Thone studied at Johns Hopkins and in 1922 obtained his Ph. D. at the University of Chicago. He served as instructor in biology at North Dakota State College and as associate professor of botany at the University of Florida before beginning his long career as a newspaperman. During the summers of 1922 and 1923, he was naturalist at Yellowstone National Park, and as a result of these experiences he published "Trees and Flowers of Yellowstone National Park" in 1923. His second book, "The Microscopic World," appeared in 1940.

Frank Thone's broad interests are emphasized by his membership in sixteen scientific organizations. He was a charter member of The Wildlife Society, and was elected to active status in 1940. In 1941 he acted as summarizer of the Sixth North American Wildlife Conference. In organization work, Dr. Thone was most active in the affairs of the American Association for the Advancement of Science. He was also a member of Sigma Xi and Phi Beta Kappa, and several cultural and civic clubs.

Frank Thone was born in Davenport, Iowa, April 12, 1891. He is survived by his mother, Mrs. Mary Anna Thone, and a sister, Margaret Thone, both of Des Moines.—LEE E. YEAGER.

WILDLIFE SOCIETY NOMINATIONS

The Nominating Committee submits the following nominees for consideration by members of the Society:

PRESIDENT

Dr. Ian McT. Cowan
Dept. of Zoology
University of British Columbia
Vancouver, B. C.

Dr. Samuel Graham
School of Forestry and Conservation
University of Michigan
Ann Arbor, Michigan

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Dr. A. Starker Leopold
Dept. of Vertebrate Zoology
University of California
Berkeley, California

Dr. D. I. Rasmussen
U. S. Forest Service
Ogden, Utah

TREASURER

Walter A. Gresh
U. S. Fish and Wildlife Service
Atlanta, Georgia

Robert D. McDowell
Pennsylvania Game Commission
Harrisburg, Pa.

Article IV, Section 2, of the Constitution, which was last published in the JOURNAL OF WILDLIFE MANAGEMENT for October 1948, outlines the nomination and election procedure which should be followed in case members would like to propose additional nominees.

The Nominations Committee

C. F. DELABARRE
ARTHUR EINARSEN
LEONARD E. FOOTE
R. L. PETERSON
SETH GORDON, *Chairman*